Industrial Education
Ventilation Study
Volume 1

Planning Services

Alberta
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Devonian Building, West Tower, 11160 Jasper Avenue, Edmonton, Alberta, Canada T5K 0L2

TO THE READER:

Enclosed is a copy of the Industrial Education Ventilation Study Volume 1 Report. Single copies of the Technical Report (Volume 2) and the Technical Appendices (Volume 3) are available for review at the School Buildings Branch of Alberta Education.

Information from the reports will be useful to those responsible for designing, using and maintaining ventilation systems in multiple activity industrial education shops. Additional information on these topics will be circulated during the next few months.

The Steering Committee responsible for the study has requested that a caution be communicated concerning the ventilation layout in Chapter 7. The Ventilation Layout for Junior High School Industrial Arts Laboratory displayed in Chapter 7 should not be used as a working drawing. It is intended to portray certain principles to be considered during design activities.

Sincerely,

H.I. Hastings

H.I. Hastings
Director
Planning Services

INDUSTRIAL EDUCATION
VENTILATION STUDY

VOLUME 1
FINAL REPORT

Prepared Under Contract to
The Calgary Board of Education, Calgary, Alberta
and
Alberta Education, Edmonton, Alberta

By
Stanley Associates Engineering Ltd.

May 1983

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20 May 1983
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LETTER OF TRANSMITTAL

Dr. A. E. Morris, Coordinator
Vocational Living Skills Group
Program Development Department
Calgary Board of Education
515 MacLeod Trail, SE
Calgary, Alberta
T2G 2L9

Dear Dr. Morris:

Reference: Final Report of the Industrial Education Ventilation Study

Enclosed is our final report of the above-mentioned study. We recognize that the Steering Committee will want to act on the recommendations contained in this report and should they wish to discuss them, please do not hesitate to contact me.

On behalf of our entire study team, this has been a most interesting research assignment. We believe that the report contents will assist you and your Steering Committee to improve significantly the quality of the industrial education shop environments throughout your respective school jurisdictions and the province of Alberta.

Yours truly,

STANLEY ASSOCIATES ENGINEERING LTD.

David A. Kinnaird

David A. Kinnaird, B.A.A., M.A., MCIP
Project Manager

/sam
Enclosure

EXECUTIVE SUMMARY

The Industrial Education Ventilation Study consists of three volumes and they are:

(i) Volume 1 — Final Report
(ii) Volume 2 — Technical Report
(iii) Volume 3 — Technical Appendices

The report was prepared under contract to the Calgary Board of Education and Alberta Education.

The general purpose of this study was to research aspects of ventilation in industrial education facilities in selected junior and senior high schools in Alberta. The major sample of schools (17) was located in Calgary and Edmonton and the schools were located in the following jurisdictions:

(a) the Calgary Board of Education;
(b) the Calgary Catholic Board of Education;
(c) the Edmonton Public School Board; and
(d) the Edmonton Catholic School District.

A smaller sample of schools, specifically one from each, was tested in the Counties of Strathcona, Leduc and Lamont school jurisdictions. A purposive sampling technique (not representative) insured inclusion of a range of conditions and a variety of equipment.

The Final Report contains:

(i) an Introduction that describes the purpose of the study and the four test methods used to acquire school specific information.

(ii) a Summary of Findings section that discusses the results of the instructors' perception survey, the ventilation systems' analyses, the dust measurements and the acoustical results.

(iii) an Issue Reformulation section that focuses attention on critical issues that have become apparent following the testing.

(iv) a Review of Regulations section that addresses acts and regulations in Alberta, British Coumbia and Ontario.

(vi) a Description of Design Standards and Guidelines section that describes working ventilation standards and discusses the globally-acknowledged concept that many industrial nations are pursuing, i.e. what constitutes tolerable exposure limits to airborne toxic substances.

(vii) a Conclusions section that summarizes observations made by the study team.

(viii) a Recommendations section that discusses both the mechanical design changes required, as well as other recommendations regarding basic issues and future research needs.

An appendix section that contains discussions regarding occupational exposure limits for airborne toxic substances and a bibliography complete the first volume.

The second volume is the Technical Report, and it discusses the analytical techniques and the results of tests.

The third volume is the Technical Appendix, and it contains the primary information relevant to the tests and surveys.

The detailed results of the tests that were conducted on the 20 selected Industrial Arts Laboratories indicated the following major defects in a large number of the test areas:

(i) high dust concentration (higher than OHS recommendations).

(ii) high noise level (higher than OHS recommendations).

(iii) insufficient make-up air (resulting in negative pressures within the laboratory area).

The following undesirable items were present in a large number of laboratory areas:

(i) large dust collection machinery with fan horsepower ranging from 10 to 25. There was no evidence that a larger dust removal system caused a lower dust level in the student area.

(ii) large dust collection hoods, with very low face velocity, resulting in poor dust capturing ability.

(iii) welding and other hot processes such as soldering and foundry, with overhead fume hoods, which encouraged the movement of the fumes past the face of the student.

(iv) plastic and ceramic areas which had no or very ineffective fume removal devices.

(v) darkroom developing areas have air changes as required by OHS, but still had perceivable chemical odours.

(vi) fan systems, while operating, did not generate sufficient air velocity to achieve the desired results.

Nineteen recommendations were contained in the Final Report of this Industrial Education Ventilation Study. They are summarized in the following way:

(i) The dust collection system size is to be based on the number of machines in use simultaneously.

(ii) Woodworking power tools are to be segregated to a separate room.

(iii) Other pollution creating processes are to be vented and are to be located on the perimeter of the laboratory.

(iv) A separate fresh air supply is to be provided for make-up air.

(v) Toxic pollutants, such as paint and engine exhaust, should be located in separate rooms with exhaust facilities.

(vi) Collection hoods are to be of a high velocity with a small face area design.

(vii) Wood lathes are to have sliding hoods.

(viii) Darkrooms are to have slot exhausts over sink areas.

(ix) Ceramic work zones should have exhaust cubicles.

(x) The laboratory area is to be maintained at slightly negative pressure to the rest of the school.

(xi) All appropriate forms of safety equipment should be worn by students and instructors all of the time in the industrial education shop.

(xii) Frequent cleaning and maintenance of dust collection systems should be arranged.

(xiii) The curriculum of industrial education and its translation into shop projects should be reviewed in order to reduce the period of interaction that the students and instructors have with activities and shop equipment which create high levels of dust.

(xiv) Regular reviews of what constitutes a hazardous and allergenic material should be undertaken for the purpose of removing the material from the industrial education shop.

(xv) Micro-computers should be removed from the industrial education shop and its environment, or should be placed in a room that is not influenced by dust and contaminants.

(xvi) Interim protective measures, i.e. personal protection, should be undertaken in industrial education shops that do not have adequate main dust collection and ancilliary ventilation equipment.

(xvii) Maintain a technical testing program in the 20 sample schools and expand it to the residual 400 schools that have industrial education shops throughout the province.

(xviii) Regularly review standards' issuing agencies for alterations of standards and substances on their toxic substances lists.

(xix) Continue research on the mechanical design of the prototypical engineering system noted in this report.

ACKNOWLEDGEMENTS

The Study Team is pleased to have had the participation of the following individuals, who comprised the Steering Committee of the Industrial Education Ventilation Study:

Dr. Al Morris, Chairperson, Steering Committee	-	Calgary Board of Education
Ms. Diane Field (Chairperson, Aug. to Dec./82)	-	Calgary Board of Education
Dr. Clarence Rhodes	-	Alberta Education, Planning Services Branch
Dr. Marian Weleschuk	-	Alberta Education, School Buildings Branch
Mr. Joe Pallas	-	Alberta Education, Curriculum
Mr. John C. Smith	-	Alberta Education, Calgary Regional Office
Mr. Joe P. Smith	-	Edmonton Catholic School District
Mr. Mike Deputat	-	Edmonton Public School Board
Mr. Keith MacKay	-	Calgary Catholic Separate Schools
Mr. Maurice Taylor	-	Occupational Health and Safety

Observers

Mr. Robert C. Baker	-	Calgary Board of Education
Mr. Ron Sidders	-	Calgary Board of Education

The members of the Study Team who contributed to this research assignment were:

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Mrs. Patti Wilson	-	Stanley Associates Engineering Ltd.
Ms. Yvonne Brown	-	Stanley Associates Engineering Ltd.
Mr. David Panar, Senior Engineer	-	Cheriton Engineering Ltd.
Mr. Joseph Ryan	-	Cheriton Engineering Ltd.
Mr. Gary Frayn	-	Envirometrics (Canada) Ltd.
Dr. Kerry Peters	-	Hardy Associates (1978) Ltd.
Ms. Mary Jorgenson	-	Hardy Associates (1978) Ltd.
Mr. David Stredulinsky	-	Wimpey Laboratories Technical Services

INDUSTRIAL EDUCATION VENTILATION STUDY

Volume 1

Final Report Draft

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SECTION 1

INTRODUCTION

1.1 PURPOSE OF STUDY

The general purpose of this study was to research aspects of ventilation in industrial education facilities in selected junior and senior high schools in Alberta. The major sample of schools (17) was located in Calgary and Edmonton and the schools were located in the following jurisdictions:

(a) the Calgary Board of Education;
(b) the Calgary Catholic Board of Education;
(c) the Edmonton Public School Board; and
(d) the Edmonton Catholic School District.

A smaller sample of schools, specifically one from each, was tested in the Counties of Strathcona, Leduc and Lamont school jurisdictions. A purposive sampling technique (not representative) insured inclusion of a range of conditions and a variety of equipment.

Areas of research pertinent to industrial education ventilation which were posed at the outset of the study were:

(i) levels of Occupational Health and Safety (OHS) regulations which can be applied;
(ii) OHS regulations being met;
(iii) how OHS regulations are being met;
(iv) current design faults in a sample of 20 schools;
(v) the meeting of curriculum and instructional requirements;
(vi) industrial education processes that need to be ventilated and controlled;
(vii) costs and relative advantages of existing and alternate systems;
(viii) optimum types of systems; and
(ix) locating the system in order to minimize problems.

The anticipated outcome of the report was to provide descriptive and judgemental information concerning levels of noise, dust and fresh air. Reference was to be made to both OHS standards and optional standards. Policy implications created by the results were to be based upon deliberations on the retention, modification or addition to existing ventilation systems now in place as well as the types required for new construction. A sample design was requested for an adequate ventilation system for use in a typical industrial education shop. Due to OHS's condemnation of industrial education ventilation in most shops, the results of this study could impact in several ways. They could be:

(a) a defensible reduction of the OHS standards if warranted;
(b) increased expenditures on existing dust collection, fume extraction and general ventilation systems;
(c) an alteration to existing human safety practices in the shops;
(d) an alteration to the root causes of the problem, not intermediate issues;
(e) an alteration to existing shop operations and practices where ventilation systems have been installed; and/or
(f) a defensible alteration to the interpretation of the OHS standards through creative design.

1.2 ASSIGNMENT OBJECTIVES

Expressed in fundamental terms, the objectives of this assignment were:

(i) to review existing regulations to determine their background and their implied standards as they influence the design of ventilation of industrial education facilities in Alberta;

(ii) to conduct tests in 20 sample schools to provide empirical values of air and noise pollutants, with particular attention paid to dust particles created through woodworking;

(iii) to comment upon the exhaust capabilities and effectiveness of existing ventilation systems in the 20 sample schools with regard to meeting prescribed standards; and

(iv) to prepare a general resolution of issues to which this report is addressed.

Several issues were identified, including primary and subordinate ones, by the contractors at the outset of the assignment. They were termed research decision points, and were considered as methodological milestones. They are discussed individually in the **Conclusions** section.

Generally, the assignment suggested that research be conducted to acquire all relevant regulations and policy documents. They would be used as background in order to assess the merits of existing regulations that prescribe current standards for industrial safety with respect to ventilation and dust control systems.

Additionally, a review of manufacturers and suppliers of equipment to assess to what degree commercially available equipment can meet optimum design standards was undertaken.

Noting diverse situations of classroom configuration, observations were made to determine what constitutes an optimum design standard with respect to OHS ventilation standards and alternate standards as applied to an industrial education shop.

Finally, to determine the most feasible approach for resolving those problems that are currently present within the sample schools, as well as to provide a base example by which Alberta Education may address the remaining 400 schools in the sample set, would be a major goal.

1.3 INSTRUCTORS' SURVEY AND SCHOOL TEST SCHEDULES

Prior to the technical evaluations of each school facility, an instructors' survey was undertaken by Stanley Associates Engineering Ltd. The purpose of the survey was to

provide initial information regarding existing conditions in each test school. Additionally, the survey was a means by which a decision regarding detailed contaminant testing could be made. The survey was delivered by hand to all of the junior high schools, which facilitated a preliminary set of observations about classroom activity.

Subsequent to the survey, an appointment was arranged with each school, using student loads and curricular activities (by grade) as the criteria. Twenty schools were formally tested, and one additional school (Colonel Irvine in Calgary) was viewed due to interest in dust collection equipment and collection hoods. The schedule of appointments is noted in Table 1.1.

Detailed testing for contaminants occurred in one school of each urban Board, and the schools were:

(i) J. J. Bowlen Catholic School, Edmonton;
(ii) Steele Heights Elementary-Junior High School, Edmonton;
(iii) Colonel Walker Community School, Calgary; and
(iv) St. Margaret Elementary-Junior High School, Calgary.

Seventeen of the twenty schools in the test sample were urban schools, all but one (John G. Diefenbaker Junior-Senior High School) of which had industrial education facilities for junior high students. The other three schools in the sample were rural junior-senior high schools.

The testing that is described in this report commenced on 10 February 1983 and concluded on 11 March 1983.

One must observe that there has been considerable enthusiasm by the industrial education instructors over the tests and that the tests, although conducted during class sessions, were observed to not interfere to any great extent with classroom activities.

TABLE 1.1

SCHOOL VISITATIONS

Day/Date	School Name	Address/Phone	Class/Grade
Thursday, 10 February 1983			
a) Morning	J. J. Bowlen Catholic School	6110 - 144 Avenue Edmonton T5A 1K5 475-3730 or 473-0686	Gr. 7
b) Afternoon	Team Meeting		
Friday, 11 February 83			
a) Afternoon	Donnan Elementary-Junior High School	7803 - 87 Street Edmonton T6C 3G6 466-8573	Gr. 8
Monday, 14 February 83			
a) Morning	St. Edmund Catholic School	11712 - 130 Avenue Edmonton T5E 0V2 453-1596	Gr. 7 & 8
b) Afternoon	Steele Heights Elementary-Junior High School	14607 - 59 Street Edmonton T5A 1Y3 478-5319	Gr. 8
Tuesday, 15 February 83			
--			
Wednesday, 16 February 83			
a) Afternoon	Balwin Junior High School	7035 - 132 Avenue Edmonton T5C 2A7 475-3646	Gr. 8
Thursday, 17 February 83			
a) Morning	D.S. MacKenzie Elementary Junior High School	4020 - 106 Street Edmonton T6J 1A6 434-3472	Gr. 8 & 9 (Per. 1-2) Gr. 9 (Per. 3)
b) Afternoon	Ottewell Junior High School	9435 - 73 Street Edmonton T6B 2A9 466-7331	Gr. 8
Friday, 18 February 83			
a) Afternoon	St. Alphonsus Catholic School	11624 - 81 Street Edmonton T5B 2S2 477-2513	Gr. 7
Monday, 21 February 83			
a) Morning	H.A. Gray Elementary Junior High School	12140 - 103 Street Edmonton T5G 2J9 477-3926	Prevoc. (Per. 1-2) Gr. 8 (Per. 3) Prevoc (Per. 4)

Day/Date	School Name	Address/Phone	Class/Grade
Tuesday, 22 February 83			
a) Morning	Parkdale Elementary-Junior High School	728 - 32 Street, NW Calgary T2N 2V9 283-8484	Gr. 8
b) Afternoon	Colonel Walker Community School	1921 - 9 Avenue, SE Calgary T2G 0V3 263-2332	Gr. 9
c) Evening	Team Meeting		
Wednesday, 23 February 83			
a) Morning	St. Rose of Lima Elementary-Junior High School	2419 - 50 Street, NE Calgary T1Y 1Z5 285-3800	Gr. 8
b) Afternoon	Dr. Gordon Higgins Junior High School	155 Rundlehill Drive, NE Calgary T1Y 2W9 285-1808	Gr. 9
Thursday, 24 February 83			
a) Morning	Sherwood Community School	2011 - 66 Avenue, SE Calgary T2C 1J4 279-7784	No students
b) Afternoon	St. Margaret Elementary-Junior High School	3320 Carol Drive, NW Calgary T2L 0K7 289-1931	Gr. 8
Friday, 25 February 83			
a) Morning	John G. Diefenbaker Junior-Senior High School	6620 - 4 Street, NW Calgary T2K 1C2 274-2240	Gr. 11
b) Morning	Milton Williams Junior High School	92 Malibou Road, SW Calgary T2V 1X3 252-7742	Gr. 9
c) Afternoon	Colonel Irvine School	412 Northmount Dr. W. Calgary	Gr. 8
07-11 March 83			
09 March 83	Ardrossan Junior-Senior High School	Ardrossan T0B 0E0 922-2228	Gr. 10, 20, 30
10 March 83	Thorsby Junior-Senior High School	Thorsby T0C 2P0 789-3983	Gr. 10
11 March 83	Lamont Junior-Senior High School	Lamont T0B 2R0 895-2228	Gr. 8/1A 30

Source: Stanley Associates Engineering Ltd.

1.4 AIR FLOW AND VELOCITY MEASUREMENTS

1.4.1 General

Cheriton Engineering and its subsidiary, Environmetrics, visited the industrial education facilities of the test schools in order to take measurements of air volumes and velocities of the various air handling systems. This included the general ventilation, dust collection and special room and area systems, such as darkroom, plastics and ceramics areas.

Special attention was given to the dust collection techniques. Capture hood velocities and the size, type and effectiveness of the exhaust system were recorded. Equipment problems (e.g. fan running backwards) were identified when they were apparent.

The test results were obtained during the "normal" operation of the laboratory. An effort was not made to maximize the performance of the dust system, such as cleaning of filters prior to measurements. Therefore, the results should not be viewed as a performance or warranty test of the equipment installed. Due to time constraints and in an effort to reduce interference with classroom operation, only one set of readings was obtained for each system, and therefore results have not been rationalized on a statistical basis.

1.4.2 Test Equipment

Two standard types of air measuring equipment were used in obtaining velocity readings. An Alnor velometer was used to obtain direct velocity readings at grills, registers and diffusers. The velometer is essentially a pressure probe on the end of a flexible rubber tube. The total pressure created by the velocity of the air is transmitted through the tube to a sensitive vane enclosed in a plastic box. The correction for the static component at the total pressure is inherent in the design, and only the velocity causes vane deflection. The deflection is proportional to air velocity, and a pointer is calibrated in feet per minute, therefore, air velocity can be

read directly. The Alnor velometer is manufactured by the Alnor Corporation of Niles, Illinois, U.S.A. Equipment details are located in Appendix D, Volume 3.

The other velocity measuring device is a small plastic fan, with very little mass, enclosed in a shroud which acts as a guide to ensure the air flows parallel to the axis of rotation of the fan. The fan surrounds a small direct current generator. The voltage generated is a function of fan speed, which in turn depends upon air velocity. The generated voltage is transmitted by a voltmeter, reading directly in meters per second. Several voltage scales can be selected, allowing readings from a minimum of 0 to 25 meters per second. The instrument and extension arm (marketed as a Direct Reading Anemometer) is manufactured by Direct Air Development Company of High Combe, England.

1.4.3 Test Procedures

Prior to the actual measurement stage, available drawings of the industrial arts laboratory were examined. This aided the test crew, normally two members, to select test equipment and arrange schedules. A "check sheet" also helped the testers to select a logical sequence of measurements. If construction drawings were not available, the first portion of test time consisted of sketching the area and ventilation systems.

Due to the inherent stability of the test equipment, no formal calibration was performed. Indicators were "zeroed" prior to readings. For small openings, only one velocity reading was calculated. For large areas, a traverse (readings at regular intervals) was obtained and an average result was obtained. For very large areas, such as hoods, maximum and minimum velocities were recorded in order to determine hood efficiencies. Notes also were made regarding the ability of various hood shapes to remove debris.

The areas of various hoods and grills were measured to obtain volumes of air moved from the velocity information. Manufacturers' data were available in most instances to convert gross grill areas to "free areas." In the cases were no firm data was available, an estimate was made of "free areas."

For record purposes, many dust collection systems were tested with some of the hoods blocked by the blade dampers provided.

1.4.4 Limitations and Accuracy of Results

The largest variable of the general ventilation readings would be due to main system characteristics. In many laboratories, ventilating air was also heating air, therefore air entering the room would be a function of outside temperature. In these instances, where insufficient general ventilation air was available, open doors allow make-up. This, in turn, would unbalance other areas of the school.

Dust control systems varied due to filter loading and number of hoods actually open to the system. Some variation also was due to the number of exhaust sytems, i.e. darkroom, welding hood and plastic area, in operation.

The "air change" method was used to give an overall indication of general ventilation rates. While this is not an absolute method of determining degree of contamination, other conditions remaining constant, higher air change would generally mean that a lower level of pollutants was present.

Some variation also existed between different hood designs and the velocity across the face of the machine operator. The most significant variant was distance of hood from the student machine-operator.

The air velocity measurements were not included to be product acceptance tests. They did, however, inform the investigators as to the effectiveness of various layouts and designs.

Most instruments that were used were accurate to $\pm$ 2.5 percent. The skill of the operator is more variable and Cheriton Engineering Ltd. has noted that test results are within $\pm$ 10 percent accurate.

1.5 DUST AND CONTAMINANT LEVELS

1.5.1 General

Hardy Associates (1978) Ltd. conducted a survey of the air quality of the industrial education shops of various junior and senior high schools, as requested by Stanley Associates Engineering Ltd. The purpose of this survey was to evaluate dust and other contaminant levels in each school, considering the existing ventilation systems.

Each school was tested for dust levels during a normal industrial education class period. Samplers were set up in various areas of the shop to monitor dust levels during routine student activities (i.e. woodworking, ceramics, etc.). In addition, a sampler was attached to the instructor to measure the overall dust level to which he is exposed during a class. These tests measured total dust levels. Occasionally, a cyclone was added to the dust sampling unit to measure levels of respirable dust.

Four schools out of the twenty were chosen for a program of greater testing. Other contaminants were studied in addition to measuring dust levels. Samples were set up to monitor levels of metal fumes in the air in areas where metal-working was in progress. Organic solvent levels were measured in plastics areas and darkrooms. Samples of dust collected were tested for silica content.

1.5.2 Sampling Equipment

Pump:

A Bendix BDX 44 Super Sampler air sampling pump was used. Each pump was calibrated in the lab with a representative filter and filter holder in line to an accuracy of $\pm$ 5%. These pumps were used in dust, metals and organic vapour measurements.

Dust Sampling:

Filter Holder: A two-piece Glasrock 37 mm field monitoring cassette with porous plastic support pad. This brand name equipment is distributed by Levitt Safety.

Filter Media: A 37 mm diameter, 0.8 µm pore size cellulose nitrate membrane filter.

Cyclone: 10 mm nylon cyclone, used with two-piece filter holder when measuring respirable dust.

Sampling Head Assembly: Assembly to rigidly hold in place the filter holder and cyclone, such that air enters only at the cyclone inlet.

Metal Fume Sampling:

Midget Impinger: Glass, standard nozzle midget impinger of 25 ml capacity, filled with 0.1 N hydrochloric acid as the absorbing solution.

Organic Vapour Sampling:

Charcoal Tubes: SKC activated charcoal tubes. This brand name equipment is distributed by Levitt Safety.

All of the above-mentioned equipment is supplied by Levitt Safety Ltd. and is National Institute for Occupational Safety and Health (NIOSH) approved. NIOSH is part of the U.S. Department of Health, Education and Welfare in Cinncinati, Ohio.

1.5.3 Sampling Methods

The methods used in monitoring the industrial education shops of the various schools are those described by NIOSH. These methods are acceptable to Alberta Occupational Health and Safety, which does not have its own published methods, but uses methods from a variety of sources, including NIOSH.

Dust Level Sampling

The amount of dust present is determined by filter weight gain during a predetermined sampling period. The filter and filter holder are assembled tightly, ensuring a good seal and weighed to the nearest 0.1 mg. If total dust is being sampled, the filter holder plugs are removed and the holder is attached to the sampling pump with a ¼"

diameter, three-foot piece of tubing. If respirable dust is being measured, the filter holder, cyclone and sampling head is rigidly assembled and connected to the sampling pump with a ¼" diameter, three-foot piece of tubing.

The filter holder or cyclone assembly is clipped onto the instructor's lapel while the sampling pump is attached to the back of his belt, if personal monitoring is being done. Otherwise, the pump and filter holder are placed at approximately breathing height in the area to be measured. The pump is switched on to begin sample collection at a predetermined flow rate, each pump having been previously calibrated with a representative filter holder and filter by means of a bubble meter. The sampling is terminated after a predetermined time, and the filter plugs are replaced in the outlet and inlet.

Following sampling, the filter is reweighed to the nearest 0.1 mg. The dust loading can then be calculated as follows:

$$\text{Dust Loading } (mg/m^3) = \frac{\text{Filter weight gain (mg)} \times 1000 \text{ (litres/m}^3\text{)}}{\text{Sampling time (min.)} \times \text{Flow rate (litres/min)}}$$

The method is described more fully in Appendix F, Volume 3.

Metal Fume Sampling

Metal fumes are measured by bubbling the air to be sampled through an absorbing solution made up of 0.1 N hydrochloric acid. To do this, a midget impinger filled with 25 ml of HCl solution is attached by means of a ¼" diameter, three-foot length of tubing to a sampling pump which has been previously calibrated for flow rate. The impinger and pump are set in an area at approximately breathing height and turned on for a predetermined length of time. At the end of the sampling period, the absorbing solution is analyzed by atomic absorption spectroscopy for its metal content. The concentration of metal fumes in the air is then calculated as follows:

$$\text{Metal fume concentrate } (mg/m^3) = \frac{(mg/l \text{ in absorbing solution}) \times \frac{25}{1000} \times 1000\ l/m^3)}{\text{Sampling Time (min)} \times \text{Flow Rate (litres/min)}}$$

The metals measured for these tests were iron, chromium, zinc, copper and nickel.

Organic Solvent Vapour Sampling

Organic solvent vapours are collected by adsorption on activated charcoal. The flame-sealed ends of the charcoal tube are broken off immediately prior to sampling. The larger section of charcoal is placed at the inlet and the smaller back-up section is positioned at the outlet leading to the sampling pump via ¼" diameter tubing. The tube and pump are placed in the desired location at approximately breathing height and turned on for a predetermined length of time. At the end of sampling, the tube is capped with the supplied plastic caps for storage.

In preparation for analysis, the tube is broken open, the glass wool discarded. The charcoal in the larger section is transferred to a small test tube. The small section is transferred to a separate tube. The two sections are analyzed separately. One millilitre of carbon disulfide is pipetted into each tube and left with occasional stirring for 30 minutes. Desorption into the carbon disulfide is complete in this time. This solution is then analysed by gas chromatography. The solvents that were checked were those listed in the Appendix which describes their TLVs and STELs.

The concentration of the organic solvent in air is then calculated as follows:

$$mg/m^3 = \frac{\text{mg Solvent in Tube} \times 1000 \text{ (litres/m}^3)}{\text{Sampling Time (min)} \times \text{Flow Rate (litres/min)}}$$

This method is described more fully in Appendix G, Volume 3.

A quick test was also performed, in some cases in addition to the above-described charcoal adsorption test. A Gastec detection tube for aromatic hydrocarbons,

calibrated for toluene is used in conjunction with a volume displacement pump to draw a specified volume of air through the detection tube. This provides a nearly instantaneous approximate reading.

1.5.4 Limitation

Aside from the inherent error in the sampling methods, which tends to be approximately five percent (ten percent for organic solvent vapours) based on sampling pump variation, there is another consideration which must be made in a study of this nature. The industrial education class activities vary considerably, both in type and intensity. This variation is found, not only from one school to another, but also from one period to another within a particular school. From measurements taken in one classroom period, it is difficult to generalize as to conditions existing during every class, and also to compare one school to another. The actual measurements themselves must be tempered with an idea of the activities during sampling. It is possible, given certain test conditions such as placement of sampler in the classroom, that readings could vary by $\pm$ 25 percent, however, any error incurred in these samples should be related to the error inherent in the sampler pump.

1.6 ACOUSTICAL MEASUREMENTS

1.6.1 General

Wimpey Laboratories Technical Services, at the request of Stanley Associates Engineering Ltd., have carried out an acoustical study of industrial education facilities in the 20 test schools.

The purpose of this study was to determine, through field testing and observation, how the existing industrial education facilities in various schools perform with respect to:

(i) noise as a health hazard;
(ii) noise as an impediment to teaching; and
(iii) room acoustics for lecturing.

The field testing and assessment was conducted by a senior acoustical engineer and the laboratory analysis of data was conducted by the same engineer and an acoustical technologist. A glossary of acoustic terms has been included in Appendix J, Volume 3, the Appendix to the Technical Report.

1.6.2 Test Procedures

A site visit was made to each school. Reverberation time measurements and measurements of the steady background or ambient noise levels were made in major areas of each facility when unoccupied. Noise level measurements were taken at the operator positions of equipment in use with regular classes in progress. Also during class activities, the typical sound levels occurring throughout the room were noted.

The reverberation time measurements were conducted by placing a precision sound level meter on a tripod at a central room location at a height of 1.4m above the floor. A loudspeaker and amplifier were then used to produce several bursts of "pink" broadband noise. During these loud bursts of noise, the audio output of the sound level meter was recorded on a magnetic tape recorder. These tape recordings were later analysed in the laboratory using a microprocessor audio analyser, which measures the rate at which the sound level decays after each noise burst from the loudspeaker. The instrument then calculates and displays digitally the reverberation time value. The reverberation time characteristics of a room depends on the frequency of sound. For this study, the times were determined for the octave bands of noise centered at 250 Hz, 500 Hz, 1000 Hz and 2000 Hz.

The background or ambient sound level in the rooms when unoccupied was measured at the same central location as used in the reverberation time test. Tape recordings of the steady background noise were taken for various conditions. They included the background noise with only the normal heating and ventilation system running, the noise with various exhaust fans and hoods running, and the noise with the dust collection system running. During each of these tests a visual reading sound level was taken with the sound level meter set on the A-weighted scale and slow meter response. The tape recordings were later analysed in the laboratory to determine the sound

levels for octave bands of frequency centred at 31.5 to 16,000 Hz. These data were used to determine the Noise Criteria (NC) rating for the room for various background noise conditions.

When the class was in progress, sound level measurements were taken at the operator positions of the power tools and machines used. The sound level meter was positioned in the vicinity of the operator's ear, and the levels were noted while the machine was running and engaging the work piece. The meter was set on the A-weighted scale and slow meter response. Some tape recordings of the noise at the operator positions were also taken and later analysed in the laboratory to obtain the octave band frequency characteristics of the machine noise. Measurements were not taken on all items of equipment at all schools. By the end of the study, representative samples of sound levels and frequency spectra were obtained for all of the significant noise producing machines used in the schools studied. This information was used in conjunction with estimates of the time that the machines were used to predict operator noise exposure. Refer to Appendix L in Volume 3 for information on the noise exposure calculation procedures used and the Alberta Occupation Health and Safety permissible limits.

During various class activities, the typical noises occurring throughout the room were noted. For these measurements, the sound level meter was set on the A-weighted scale and slow meter response. This information was used primarily to access potential problems with communication within the classroom.

1.6.3 Instrumentation

The instrumentation and equipment used in this study is summarized below. Relevant instrument specifications are listed in Appendix K, contained in Volume 3.

For the reverberation time testing, the following equipment was used:

Noise Source:
- I.E. - 20B Pink Noise Generator
- McMartin LT250C Power Amplifier
- Spectrum - SGE-102 Graphic Equalizer

	-	Musicaster IIA Loudspeaker
Field Data Acquisition	-	Precision Sound Level Meter Bruel and Kjaer, Type 2203
	-	Magnetic Tape Recorder Nagra, Type IV-D
Lab Analysis	-	Audio Analyser IVIE Electronics Inc. Type 1E 30A/ 17A
	-	Magnetic Tape Recorder Nagra, Type IV-D

For the measurement of sound levels, including background noise levels, machine noise levels and typical room activity noise levels, the following equipment was used:

Field Data Acquisition	-	Precision Sound Level Meter Bruel and Kjaer, Type 2203
	-	Magnetic Tape Recorder Nagra, Type IV-D
Lab Analysis	-	Magnetic Tape Recorder Nagra, Type IV-D
	-	Audio Analyser IVIE Electronics Inc., Type 1E 30A/ 17A
	-	X-Y Plotter, Hewlett Packard, Type 7034A

1.6.4 Limitations and Constraints

The reverberation time measurements are normally taken for octave bands or third octave bands of noise from 125 Hz to 4000 Hz. For this study, in order to minimize analysis time, only the bands from 250 Hz to 2000 Hz were reported. They are the most critical bands when considering intelligibility of speech within a room.

The ambient noise levels in the rooms when unoccupied were measured at one central location in the room. There can be some variation in the sound level throughout the room, particularly at low frequency. Also, in the vicinity of the noise sources such as air supply and return grills, fan units, etc., the noise level can be several dB higher depending on the distance from the source and the room reverberant qualities. The measured value should, however, be sufficiently accurate to provide a reasonable assessment of communication capabilities within the room.

The measurement of noise levels at the operator position of a particular machine should reasonably represent the noise to which his ears are exposed for that particular operation. It should be noted that generally the major noise produced by most machines or tools is caused by the interaction of the machine and the work piece and in some cases most of the noise may actually be radiating from the vibrating workpiece. For a particular machine, variation in sound level of 10dBA or more may occur when using different materials and sizes and shapes of work pieces. Similarly, the sound level can depend on operator controlled parameters such as the alignment of the workpiece or the amount of pressure on it.

The specific movements of the instructor or individual students throughout the class were not documented. This would be extremely difficult and beyond the scope of this study. There also will be considerable variation between classes, depending on the teacher, students, specific projects underway, etc. In order to obtain some upper limits on the possible noise exposure of teachers and students, predictions have been made assuming the teacher or student uses the noisiest machines continuously for the entire daily class time.

These limits are probably above the actual noise exposures, but should at least pinpoint potential problem areas. The instructors usually distribute their time between many areas, and probably only demonstrate the use of a particular machine for a short period. Their actual noise exposures may be possibly only 25 percent of maximum values predicted in this report. An extensive study over a longer period of time using personal noise dosimeters worn by the instructors and/or students would be required to obtain more accurate information.

SECTION 2

SUMMARY OF FINDINGS

A great deal of information about the 20 test schools has been recorded in Volume 2, Technical Report, supported by Volume 3 Appendices. One must state that the observations were made in the 20 sample schools at times during which it was assumed that average activities were undertaken by numbers of students which would contribute to a large class load. Further, it was assumed that this load would be near the maximum level that any instructor would face during a school year.

2.1 INSTRUCTORS' PERCEPTIONS OF CONDITIONS IN THEIR SHOPS

Ninety percent of all materials areas in the sample schools were viewed by their instructors as having "dusty conditions," although only 55 percent of them were noted as having occasionally stuffy conditions. A summary is stated in Table 2.1. It was noted that in almost all of the 90 percent sample that the instructors perceived a ventilation problem. These high values suggest that a review into the shop air conditions was warranted indeed.

Seventy-five percent of the (materials) industrial education shops were viewed to be noisy to the extent that instruction was distracted.

2.2 VENTILATION SYSTEMS

The types of ventilation systems in each test school's industrial education shop are noted in Table 2.2.

TABLE 2.1

INSTRUCTOR PERCEIVED PROBLEMS WITH INDUSTRIAL EDUCATION SHOPS

	Materials Area Conditions			
School	Occasionally Stuffy	Dusty Conditions	Ventilation Problem in Shop	Instruction Distracting Noise
Parkdale	X	X	X	
Colonel Walker		X	X	X
Dr. Gordon Higgins	X	X	X	X
Sherwood	X	X	X	X
John G. Diefenbaker	X	X	X	X
Milton Williams		X	X	X
St. Rose of Lima	X	X	X	
St. Margaret	X	X	X	
Donnan		X	X	X
Steele Heights		X	X	X
Balwin			X	X
D.S. MacKenzie	X	X	X	X
Ottewell	X	X		X
H.A. Gray		X	X	X
J.J. Bowlen	X	X		X
St. Edmund				X
St. Alphonsus		X		X
Ardrossan	X	X	X	X
Thorsby	X	X	X	
Lamont		X	X	X

Source: Industrial Education Ventilation Study Survey
Stanley Associates Engineering Ltd.

TABLE 2.2

SUMMARY OF VENTILATION AND DUST CONTROL SYSTEMS

School	Dust Extraction System	Extraction Systems by Location				
		Plastics	Welding	Paint	Engine	Metal
Parkdale	T - 7.5 hp	X	X	X	X	—*
Colonel Walker	M - 10 hp	X	X	X	X	X*
Dr. Gordon Higgins	A - 7.5 hp	X	X	X	X	X*
Sherwood	A - 25 hp	X	X	X	X	X*
John G. Diefenbaker	M - 15 hp	—**	X	X		X*
Milton Williams	T - 7.5 hp	X	X	X	X	X*
St. Rose of Lima	Shop Vac		X		X	
St. Margaret	No Central			X	X	X
Donnan	No Central				X	X
Steele Heights	Shop Vac	----------General exhaust for area----------				
Balwin	M - 10 hp					X
D.S. MacKenzie	No Central	----------Gravity Exhaust----------				
Ottewell	T - 5 hp			X		
H.A. Gray	T - 5 hp				X	—*
J.J. Bowlen	M - 10 hp			X	X	
St. Edmund	M - 10 hp				X	
St. Alphonsus	M - 10 hp				X	
Ardrossan	M - 20 hp	X	X	X	X	
Thorsby	None		X	X		
Lamont	None		X	X		

Legend

T - Torit

M - Murphy

A - American Air Filter

All schools with darkrooms had darkroom exhausts or supply fans.

* These schools also have ventilation in graphics areas.

** This school also has ventilation in the ceramics area.

Source: Cheriton Engineering Ltd.

The schools that were selected for testing purposes varied in ventilation and dust collection equipment from a minimum application (Lamont and Thorsby) to an extensive application (Diefenbaker, Sherwood and Ardrossan). Programs, that is grade levels and their inherent curriculum and numbers of students differed from school to school. The maintenance of ventilation and dust collection systems also varied and may have influenced results. Industrial education instructors were, without exception, most cooperative and helpful, however, variation in student assignments and supervision was apparent. Nevertheless, some general conclusions can be made as follows:

(i) schools with an independent source of make-up fresh air seemed to cause minimum negative pressure problems and give consistent results with exhaust systems (the Calgary Board of Education's Milton Williams Junior High School would be an example);

(ii) efficiency of dust pick-up depended somewhat on velocity in the pipe, but was influenced more by hood shape and proximity to the work. Movable hoods such as those in the Calgary Board of Education's Sherwood Community School and Milton Williams Junior High School worked much better than large area hoods such as that found in the Edmonton Catholic School District's J.J. Bowlen;

(iii) small exhaust grills in high ceilings, even when placed over ceramic and plastic areas, had no perceptible effect, in fact, one had to listen for fan noise to determine if the fan was switched on or off;

(iv) large area hoods placed above welding areas may do more harm than good, since the fumes gradually move upwards, allowing the operator more time for inhalation;

(v) special exhaust systems for plastics areas should have large indicating lights, to note whether or not the special exhaust system is operating, since dust collection system noise prevents hearing other systems; and

(vi) All dust collection systems on wood lathes did not prevent small dust particles from adhering to the inside of the face mask worn by students. This implies that existing systems are not removing dust from the operator's face.

2.3 DUST LEVELS

A few general points can be made when considering all of the schools tested. In particular, it may be noticed that the dust levels measured in each school appear to be related both to the presence of a dust collection system and to the level of the woodworking activity. The level of dust determined for each instructor is noted in Table 2.3, and for area measurements (as low to high) is noted in Table 2.4. Also, the tables show the presence or absence of a dust collection system, and the level of woodworking activity. This last category is defined as low to high through a value judgement, considering the number of students woodworking, nature of work, use of machines and duration of work. In these tables, a definite correlation between dust level and activity level can be seen, irrespective of the dust collection system. The effect of the dust collection system in use seems to be masked by the overriding effect of the activity level.

In most schools, excepting Parkdale, St. Rose of Lima, Donnan, Steele Heights, H.A. Gray and St. Alphonsus, the dust level to which the instructor was exposed exceeded the Alberta OHS of 5 mg/m^3 for an 8 hour work day and 10 mg/m^3 for a 15 minute interval respectively for non-allergenic wood dusts. Area measurements also frequently exceeded these limits. Students therefore would be exposed periodically to dust levels for short time periods that could be considered harmful.

From visual observation, it would appear that the major dust-contributing factors are the wood lathes and sanders. Other machines and activities generate dust as well, but these in particular seem to create clouds of dust, even when dust collectors are attached, in some cases.

TABLE 2.3
COMPARISON OF INSTRUCTOR TOTAL DUST LEVELS TO DUST COLLECTION SYSTEM AND ACTIVITY

School	Dust Level	Dust Collection System	Woodworking Activity
Parkdale	low	yes	low
Colonel Walker	high	yes	medium
Dr. Gordon Higgins	high	yes	medium
Sherwood	not measured	yes	none
John G. Diefenbaker	high	yes	high
Milton Williams	high	yes	high
St. Rose of Lima	low	no (woodworking in separate room)	medium
St. Margaret	high	no	medium
Donnan	low	no	low
Steele Heights	medium	no	medium
Balwin	high	yes	medium
D.S. MacKenzie	high	no	high
Ottewell	high	yes	high
H.A. Gray	medium	yes	low
J.J. Bowlen	high	yes	high
St. Edmund	high	yes	medium
St. Alphonsus	low	yes	low
Ardrossan	high	yes	high
Thorsby	very high	no	medium
Lamont	very high	no	medium

Dust Level Legend

High = more than 15 mg/m^3 total dust

Medium = 11 - 15 mg/m^3 total dust

Low = 0 - 10 mg/m^3 total dust

Measured by sampler worn by instructor.

Source: Hardy Associates (1978) Ltd.

TABLE 2.4

COMPARISON OF AREA DUST LEVELS TO DUST COLLECTION SYSTEM AND ACTIVITY

School	Dust Level			Dust Collection System	Woodworking Activity
	Woodworking	Ceramics	General		
Parkdale	—	—	low	yes	low
Colonel Walker	high	—	—	yes	medium
Dr. Gordon Higgins	high	—	low	yes	medium
Sherwood	—	—	low	yes	none
John G. Diefenbaker	high	—	high	yes	high
Milton Williams	high	—	high	yes	high
St. Rose of Lima	medium	medium	medium	no (woodworking in separate room)	medium
St. Margaret	very high	high	—	no	medium
Donnan	high	—	low	no	low
Steele Heights	very high	high	high	no	medium
Balwin	high	—	low	yes	medium
D.S. MacKenzie	high	—	medium	no	high
Ottewell	very high	—	high	yes	high
H.A. Gray	high	—	medium	yes	low
J.J. Bowlen	high	low	—	yes	high
St. Edmund	high	—	low	yes	medium
St. Alphonsus	—	—	medium	yes	low
Ardrossan	high	—	high	yes	high
Thorsby	very high	—	very high	no	medium
Lamont	very high	high	—	no	medium

Dust Level Legend

Very High = more than 50 mg/m^3 total dust
High = 16 - 50 mg/m^3 total dust
Medium = 11 - 15 mg/m^3 total dust
Low = 0 - 10 mg/m^3 total dust

Source: Hardy Associates (1978) Ltd.

Dust collection systems are present in a number of schools, i.e. Colonel Walker, Dr. Higgins, and St. Edmund, but infrequently are used due to noisy operation. The instructors feel that the noise from these units interferes with their ability to communicate with the students.

The greatest amount of dust is generated in woodworking areas, due to the operation of certain machines, i.e. lathes; however, other areas where dust creates some problem are ceramics and cement pouring. These areas often exceed the stated dust levels, and no controls are present in the schools.

It should be noted that the type of dust to which the instructor and students are exposed is important, and in the case of woods, whether it is allergenic or non-allergenic.

In the four schools which were chosen for detailed study, neither organic vapours nor metal fumes appeared to be a problem, but organic vapours were detected at the 20 ppm level using Gastec detection tubes. Aromatic hydrocarbons were detected in the fume hood of Colonel Walker Community School while the spraying of an organosilicon mould release product was in progress, and hydrocarbons were detected near the plastics oven at J. J. Bowlen Catholic School.

2.4 ACOUSTICAL RESULTS

It appears that 5 of the 20 shops, or 25 percent, had reverberation times that were above those values recommended for good speech intelligibility, as shown in Table 2.5. Three others were above the values, but were marginally acceptable.

The other test in this classification was for noise and the potential for exceeding OHS noise exposure limits was calculated. It appears that there is the possibility that instructors in 50 percent of the shops may exceed the limits, depending on what activities they sustain and that students in two of the schools (ten percent) may also exceed the limits.

TABLE 2.5

ACOUSTICAL RESULTS

School	Shop Reverberation Time Compared to Recommended Values for Good Speech Intelligibility			Exceeds OHS Noise Exposure Limits*	
	Close to Optimum	Above but Acceptable	Above	Instructor	Student
Parkdale	X			No	No
Colonel Walker	X			No	No
Dr. Gordon Higgins	X			No	No
Sherwood		X		Possibly	No
John G. Diefenbaker	X			Possibly	No
Milton Williams	X			Possibly	No
St. Rose of Lima	X			Possibly	No
St. Margaret		X		Possibly	No
Donnan		X		No	No
Steele Heights	X			Possibly	No
Balwin			X	Possibly	No
D.S. MacKenzie	X			No	No
Ottewell	X			No	No
H.A. Gray			X	No	No
J.J. Bowlen	X			Possibly	Possibly
St. Edmund	X			No	No
St. Alphonsus			X	No	No
Ardrossan			X	Possibly	Possibly
Thorsby			X	No	No
Lamont	X			Possibly	No

* Under normal classroom conditions

Source: Wimpey Laboratories Technical Services.

SECTION 3

ISSUE REFORMULATION

3.1 SCOPE OF THE PROBLEM

It is clear from the magnitude of the test findings that the scope of the problem is generally greater than that of the instructors alone. The test findings imply that the scope of the assignment is larger than expected and is a worst case scenario in which the health of the instructor and the students is involved. Students are not explicitly described as dependents of the School Boards in any legislation related to ventilation of industrial education facilities. The issue now encompasses that of determining to what extent the health of the students should be protected, what should be prescribed as ameliorating actions and who should bear what proportion of that responsibility. This clearly is a subset of the total issues and they include the instructors' safety.

Further one must question the nature of what would constitute a representative sample of industrial education facilities' conditions, bearing in mind the question: What would be found if the 20 sample schools were some of the better ones, better being defined by having more effective dust extraction systems than in any other schools? The answer to this question is beyond the scope of this assignment but the question demands an answer.

3.2 PARAMETERS OF THE PROBLEM

The same parameters that influenced the testing of the industrial education ventilation facilities are those that must be considered in any solution. They are:

(i) curriculum content;
(ii) degree of use of dust creating machinery;
(iii) ventilation system design and school layout;

(iv) instructor volition to enforce safety and air quality in the classroom; and

(v) student loads on the industrial education facilities.

The curriculum content defines the learning experiences that are considered desirable and they include the shop equipment that is to be used to complete certain projects, as well as the type and amounts of materials to be used. Further it influences the second parameter, machine usage that is comprised of machine type, duration and frequency of use. Also it is influenced by the inherent opportunity for dust extraction (ie) fixed versus hand held equipment. The third parameter, ventilation systems design is influenced by commercial equipment capabilities and design innovations through field research. The fourth parameter, instructor volition is partially influenced by instructor perceived priorities in the classroom, student reaction to (safety) instruction and the school jurisdiction's enforcement of safety standards. The fifth parameter, student loads, is influenced by enrolment size, distribution and the emphasis placed upon the need to instruct in industrial education.

Additional parameters include:

(vi) school jurisdiction and Alberta Education volition to resolve these issues;

(vii) the definition of the amplitude of the measures to be taken to resolve these issues;

(viii) the volition of any school jurisdiction and Alberta Education to further explore the broader scope, that is the parameters of the problem; and,

(ix) the volition on the part of Alberta OHS Branch to accept alternate design considerations as a solution to the problem.

SECTION 4

REVIEW OF REGULATIONS

The purpose of this section is to review all relevant acts, regulations and policy documents as a background to assessing current standards for industrial ventilation and dust control systems. Firstly, the chronologic development of the Alberta Occupational Health and Safety Act is summarized, illustrating the gradual and unsystematic formation of the legislation. Secondly, the Alberta acts and regulations, and national codes with which a designer in Alberta must comply are identified. Thirdly, the relevant legislation in Ontario and British Columbia is summarized for purposes of comparison and the activities of the Ministry of Education in those two provinces are examined. Lastly, the legislated responsibilities of Alberta Workers' Health, Safety and Compensation's Occupational Health and Safety Branch Division noted, to show what powers the government has for the enforcement of industrial safety.

4.1 THE DEVELOPMENT OF THE OCCUPATIONAL HEALTH AND SAFETY ACT IN ALBERTA

The history of the Alberta Occupational Health and Safety Act may be traced briefly as follows. The original Workmen's Compensation Act c. 12 was proclaimed in 1908 joined by the Workmen's Compensation Act (Accident Fund) c.5, 1918 under which the first Workmen's Compensation Board (WCB) was constituted. These two separate acts were brought together in 1938 with An Act to Amend and Consolidate the Workmen's Compensation Act (Accident Fund) c.23. The act evolved into the Workers' Compensation Act, c.87, 1973 and was accompanied by seven regulations dealing with Building and Excavating (365/173), First Aid (56/74), General Accident Prevention (363/73), Grain Elevators and Mills (48/66), Lumber Industry (366/73), Petroleum and Natural Gas Industry (360/73), and Explosives (364/73). These regulations developed gradually over a period of twenty years, in response to perceived needs. The Alberta Public Health Act and Regulations whose constituents are viewed as contributers include:

Division 11, Lead (4/72), Division 20, Occupational Health (298/72 and 3/73), Division 25, Fibrosis of the Lungs (375/71), Division 40, Notification of Industrial Disease (62/70).

An Industrial Health and Safety Commission was appointed in 1973 to study the state of Occupational Health and Safety in Alberta, and to recommend directions for the future[1].

Among other decisions, the Commission concluded that jurisdiction over occupational health under the existing system was inefficient due to its division between too many departments and agencies. The Commission recommended the formation of a new Department of Occupational Health and Safety which would report to the same Minister as the WCB.

Although these recommendations were not adopted, a reorganization did take place in 1976. The Accident Prevention Department of the WCB was transferred to the Department of Labour, forming a new Occupational Health and Safety Division. The Occupational Health and Safety Act c.40, 1976 was given assent on May 19, 1976, and the seven regulations under the Workmen's Compensation Act were reissued under the OHS Act. The Workers' Compensation Act was retained to legislate details regarding compensation, penalties, and payments.

On March 23, 1979, Mr. W. Diachuk was appointed Minister of Workers' Health, Safety and Compensation and the OHS division was transferred over from the Department of Labour.

Since March 1976, a number of new regulations have been added to the OHS Act, covering such topics as Asbestos, Chemical Hazards, Silica, and Designation of Serious Injury.

The regulations are undergoing frequent re-evaluation and a major revision of the General Accident Prevention Regulations 267/76 is planned for January 1983.

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1 Report of the Industrial Health and Safety Commission, 1975, p.8.

4.2 A REVIEW OF ALBERTA ACTS AND REGULATIONS APPLICABLE TO INDUSTRIAL EDUCATION FACILITIES

A number of acts, regulations and guidelines are relevant to industrial arts facilities, including ventilation, dust control, storage of hazardous substances and electrical supply.

1. Hazardous Chemical Act RSA 1980, c.H-3 s.6 . If the use, handling, storage, etc. of a hazardous chemical is a health and safety risk, a "chemical control" order may be issued to the person responsible.

2. Occupational Health and Safety Act; General Accident Prevention Reg. 267/76

   Flammable liquids or harmful substances must be stored in approved containers, with contents marked on the outside. Storage procedures must meet fire regulations.

3. Electrical Protection Act RSA 1980, c.E-6 The Electrical Protection Act requires that one must comply with the Canadian Electrical Code CSA - C22.1 - 1982, and the Quarterly Bulletins issued by Alberta Labour, Electrical Protection Branch. Although the Canadian Electrical Code does not deal with schools in particular, many of its regulations are applicable. Section 18, Hazardous Locations regulates locations containing hazardous or flammable gases, vapours or dusts. For example, ventilating pipes for a rotating electrical machine located in a hazardous location shall be vented to the outside of the building. (s.18-212).

4. National Fire Code of Canada 1980 s.4.2.6. Fire regulations for container storage of flammable and combustible liquids in educational occupancies are stated. Briefly stated, quantities must be limited to minimum essential amounts, and stored in safety containers conforming to ULC-C30-1974 "Metal Safety Cans."

5. School Buildings Act RSA 1980 c.S-4 s.4 Regulations may be made prescribing requirements that must be met before a school is constructed or renovated.

School Buildings Regulations 1979 (with amendments to Dec. 31, 1981)

Tables give the maximum area per pupil according to "Fixed Capacity" for industrial education facilities in elementary, junior, and senior high schools.

6. Alberta Building Code 1981 According to regulation 128/81 or the Uniform Building Standards Act, the National Building Code of Canada 1980 shall be adopted as the Alberta Building Code. The code applies to most aspects of school facility construction, including structural design, wind and water protection, HVAC, plumbing, and fire performance rating. Part 6: Heating, Ventilating and Air-Conditioning is a combination of specific regulations and general guidelines on such topics as air ducts, heaters, incinerators, refrigerating systems and chimneys. Frequent reference is made to practices and standards of ASHRAE, CSA, NFPA, ULC, ASTM and SMACCNA.*

7. Public Health Act RSA 1980, c.P-27. The Act specifies that schools are included in its jurisdiction and that regulations regarding lighting, heating ventilating and plumbing may be made. (s.1 (g) i; 6 (b)) School children are included by inference in the term "public".

Nuisance and General Sanitation Regulation (Division 34) Reg. 95/1973 s.34-3-2 (g) Schools or educational facilities must not be dangerous to health due to "lack of ventilation sufficient to render harmless any gases, vapors, dust or other impurities generated in the premises."

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* American Society of Heating, Refrigerating & Air-Conditioning Engineers, Canadian Standards Assoc., National Fire Protection Assoc., Underwriters' Laboratories of Canada, American Society for Testing & Materials, Sheet Metal & Air-Conditioning Contractors' National Assoc.

8. Fire Prevention Act RSA 1980 c.F-10 s.35. All outer and main inside doors in schools must open freely outwards, and may not be locked or barred during operating hours. s.41 Regulations governing "locations, construction, occupancy, equipment and general fire safety of .... schools" may be enacted.

Alberta does not have its own fire code, but follows the National Fire Code of Canada 1980. Industrial education facilities should comply with all relevant fire regulations, particularly those dealing with spray booths (s.5-12) welding and cutting (s. 5.17), container storage of flammable and combustible liquids in educational occupancies (s.4.2.6), and dust producing processes (s.5.10).

9. Occupational Health and Safety Act RSA 1980 c.0-2. The act primarily describes the operating procedures of the Occupational Health and Safety Council. Regulatory details are provided in the seventeen different regulations, eight of which are applicable to industrial arts classrooms.

Designation of Occupations Regulation Reg. 288/76.

Teaching, clerical and custodial staff are designated as occupations covered by the OHS Act. Note that school children are not protected under this Act.

Designation of Serious Injury and Accident Regulation Reg. 298/181.

Injury and accidents that might occur in a school shop, such as "unconsciousness that results from asphyxiation or electrical contact" or the accidental release of a hazardous substance are eligible for compensation.

Chemical Hazards Regulations Reg. 8/82

This regulation sets limits on a person's exposure to airborne chemical hazards, including acrylic acid, ammonia, copper fume, nonallergenic and allergenic woods dust, welding fumes, turpentine and many other substances potentially found in industrial education facilities.

Noise Regulation Reg. 314/81, amended by 439/81, 85/82.

If a worker's daily exposure to steady and impulse noise exceeds the maximum permitted duration per day (eg 85 dBA for 8 hours/day), the employer must provide hearing protectors, post warning signs, fill in reports and the worker must have regular audiometric testing.

General Accident Prevention Regulations Reg 267/76.

Several Sections of this regulation apply to safety within industrial arts facilities.

s.18-20, 25	General Safety Precautions
s.31	Housekeeping
s.79-95	Ventilation - General Requirements
s.96-101	Spray Painting
s.102-104	Protective Coatings
s.105-107	Welding
s.108-118	Abrasive Blasting
s.119	Cleaning Hoods
s.125-132	Garage - Vehicle Repair Shops
s.138-140	Control of Dust
s.141	Illumination
s.142	Noise
s.143-145	High Temperature Hazards
s.156-158	Transferring Flammable Liquids and Powdered Materials
s.163	Signs and Barricades
s.226	Grinding
s.357-366	Welding
s.394-445	Woodworking

Silica Regulation 9/82

Silica dust that may be present in ceramics or pottery classrooms must be cleaned away either by wet sweeping or a filtered vacuum cleaner. Airborne concentrations must be maintained below threshold levels.

Others

Additionally, one must review the First Aid Regulation (299/81, and 85/82).

10. Worker's Compensation Act RSA 1980, c.W-16.

This act deals primarily with administrative procedures concerning compensation payment, and is not relevant to this study, but has supplied background components to the OHS Act.

11. Design Criteria for the Control of Health Hazards in Schools. Alberta Workers' Health, Safety and Compensation, Occupational Hygiene Branch, 1978.

As stated in the booklet's introduction; "the general lack of information on the design needs for specific areas necessitated the production of a set of guidelines for people involved at the planning stage" of science, vocational, industrial and fine arts facilities. After dozens of interviews and school inspections, an inventory of the types of health hazards present and methods of control for the different work areas was prepared.

Requirements for local and general ventilation systems, optimal layout of exhaust hoods and fans, minimum capture velocities, number of air changes, and noise levels are specified for the work areas of plastics, metalworking, fine arts, woodworking, duplicating, automotives, beauty culture, ceramics, music rooms, photography and science labs. Standards are based largely on the Occupational Health and Safety regulations, ASHRAE Fundamentals, and the American Conference of Governmental Industrial Hygienists' Industrial Ventiliation Manual.

The booklet has been distributed to all school boards in the Province.

4.3 BRITISH COLUMBIA ACTS AND REGULATIONS

It is useful to examine the activities in British Columbia and Ontario regarding industrial education facilities, and note the relevant legislation in force in these provinces.

The British Columbia Ministry of Education has not conducted any studies into ventilation, noise control, or dust control in industrial arts facilities. Their new "B.C. School Building Manual" does not contain a section on HVAC, and they have not written any standards or guidelines in this area.

Before B.C. Education grants funds for school construction, safety regulations of the Insurance Corporation of B.C. (ICBC) must be met. ICBC has bulletins governing such concerns as fire walls, fire and intruder alarms, and sprinkler systems but has not any bulletins on noise and ventilation. However, ICBC also enforces standard codes including the National Fire Code of Canada, the National Building Code of Canada, CSA Standards, and ASHRAE handbooks, which include regulations on ventilation.

Various legislation in British Columbia is applicable to industrial education facilities. School teachers and staff are protected by the Workers' Compensation Act RSBC 1979 c.437, and in particular by the Industrial Health and Safety Regulations 585/77. These regulations combine in one document all the concerns covered by the Alberta OHS regulations. Ventilation systems should be in accordance to the American Conference of Governmental Industrial Hygienists Industrial Ventilation Manual. As in the Alberta regulations, ventilation systems in areas with hazardous gases, fumes, or dusts must maintain airborne concentrations of the contaminants below specified levels. Noise level guidelines are very similar to those in Alberta.

Students who are over 15 years of age and participating in a work study - work experience program are also eligible for compensation under the Workers' Compensation Act.

All students fall under the jurisdiction of the Health Act RSBC 1979, c.164, which provides protection against any type of health hazard.

Finally, British Columbia, like Alberta, has adopted the National Building Code of Canada as their Building Code Act c.290 and regulations.

4.4 ONTARIO ACTS AND REGULATIONS

The Ontario Ministry of Education has not published any studies about ventilation, noise nor dust control in industrial arts classrooms. They have not written any standards, regulations or guidelines in these areas.

Certain Ontario legislation does impact on industrial education facilities. The Building Code Act RSO 1980 c.51 and regulations is an expanded version of the National Building Code, and contains requirements for heating, ventilating and air conditioning. The Occupational Health and Safety Act, Industrial Establishments Reg. 692 specifies maximum noise levels and states general principles to which a ventilation system should adher. However, the Act applies to clerical and custodial staff but not to school teachers.

The Public Health Act RSO 1980, c.409 protects the health of school children and gives the province the right to investigate any schoolhouse that is not adequately ventilated to remove hazardous gases, vapours, or dust. The Ontario Ministry of Health has just published a set of guidelines relating to environmental health inspection in schools, which may in future become ministerial guidelines.

Various school boards in Ontario are concerned with industrial ventilation problems. The Scarborough Board of Education has taken many steps towards improving ventilation systems in areas such as woodworking or fine arts. For instance, toxic fumes from art chemicals must be exhausted with a horizontal pull, rather than vertically past the face of the worker. The Carleton Board of Education has installed dust precipitators and hired a safety officer to advise them on equipment installations. The Ottawa Board of Education has just initiated a study of air quality and dust

control in industrial arts facilities. The Toronto Board of Education has not performed any studies, but has hired an Occupational Health and Safety Officer. Their schools are constantly involved in rectifying ventilation problems.

4.5 LIST OF ACTS AND REGULATIONS RELEVANT TO INDUSTRIAL ARTS FACILITIES

Provincial legislation in Alberta, British Columbia and Ontario that is applicable to ventilation, noise and industrial safety in industrial education facilities has been summarized in Table 4.1. All three provinces have a building code act that is based largely on the National Building Code of Canada, making the basic requirements for HVAC systems the same in these provinces. All have a form of industrial or occupational safety act and regulations, although the Alberta and British Columbia legislation is much more comprehensive in the types of hazards covered and specific safety measures require - a health act is present in each province, with wide powers to protect the health and safety of school children. Each of these provinces relies primarily on the Canadian Electrical Code and the National Fire Code of Canada for electrical and fire standards, although supplementary requirements for safety and inspection are given in provincial acts.

4.6 LEGISLATED RESPONSIBILITIES

Alberta Workers' Health, Safety and Compensation, Occupational Health and Safety Division

Occupational Health and Safety Council may:

- Advise Minister
- Hear appeals
- Perform other duties assigned by Minister

Officer may:

- Inspect any worksite
- Make copies of any records, books, plans relating to health and safety

TABLE 4.1

LIST OF ACTS AND REGULATIONS RELEVANT TO INDUSTRIAL EDUCATION FACILITIES

Alberta	British Columbia	Ontario
1. School Building Act RSA 1980, c.S-4 - School Building Reg.	1. School Act - not applicable	1. No School or School Building Act
2. Uniform Building Standards Act RSA 1980, c.U-4 - Alberta Building Reg. 128/81 - Alberta Building Code 1981 (equivalent to National Building Code) - Standard Bulletins	2. Building Code Act c.290 & Reg. - (Equivalent to National Building Code)	2. Building Code Act RSO 1980 c.51 - Building Code Regulations 87
3. Occupational Health and Safety Act RSA 1980, c.0-2 - Chemical Hazards Reg. 8/1982 - Noise Reg. 324/81 - Designation of Serious Injury & Accident Reg. 198/81, 440/81 - Designation of Occupations Reg. 288/76 - General Accident Prevention Reg. 267/76 - Silica Reg. 9/82	3. Workers' Compensation Act RSBC 1979, c.437 - Industrial Health and Safety Regulations 585/77, 374/79 - Students Work Study Reg.674/74	3. Occupational Health and Safety Act - Industrial Establishments Reg. 692
4. Public Health Act RSA 1980, c.P-27 - Nuisance and General Sanitation Reg. 95	4. Health Act RSBC 1979, c.161	4. Public Health Act RSO 1980, c.409
5. Hazardous Chemical Act RSA 1980, c.H-3	5. No Act	5. No Act
6. Electrical Protection Act RSA 1980 c.E-6 - Quarterly Bulletins	6. Electrical Energy Inspection Act RSBC, c.104	6. No Act
7. Fire Prevention Act RSA 1980 c.F-10	7. Fire Services Act RSBC, c.133	7. Fire Marshalls Act RSO, c.166

Source: Stanley Associates Engineering Ltd.

- Inspect, seize any tool, material, equipment produced, used, or found at work site.
- Take tests, photographs, recordings, interviews.
- Order in writing that work is stopped.
- Order that measures be taken to make work safe, within time limits.
- Order any worker to leave unsafe worksite.
- Be accompanied by a peace officer to enforce orders.
- Order worker to stop using unsafe tool or equipment, or a supplier to stop supplying unsafe tool or equipment.
- Order repair or modification of above.
- Order safe handling, storage or use of a substance as prescribed in the regulations.
- Investigate an accident.

Minister may:

- Appoint Chairman and Vice-Chairmen of Council.
- Enter into an agreement with any person or government regarding research, training programs, first aid programs.
- May exchange information on accidents, occupational diseases, assessments, operations of employers with Workers' Compensation Board.
- Require establishment of joint work site health and safety committee
- Appoint a board of inquiry.
- Make assessments on employers.
- Make grants.

Lieutenant Governor in Council may:

- Appoint Occupational Health and Safety Council.
- Make regulations under the Act.

Director may:

- Require contractor or employer to regularly inspect worksite for occupational hazards.
- Order contractor or employer to establish code of safe working practice, to be posted in conspicuous location.
- Assume any of the duties of an Officer.

Director of Inspection may:

- Apply for a court order requiring a person to comply with order made by any Director, Officer, or Member of the Council.

Director of Medical Services may:

- Require injured worker to be medical examined by authorized physician.
- Require that if a worker is employed in a hazardous occupation, employer registers worker's name and worksite, worker has regular medical examinations, certain medical records be kept.

Director of Inspection or Director of Occupational Hygiene may:

- Designate any work as a project.
- Order any unsafe project stopped, until safety measures complied with.
- Order person to furnish drawings, plans, specifications to show workers' safety will be protected.

Also, the OHS Act provides commentary regarding legislated responsibilities for the employer, worker, supplier and principal contractor.

4.7 DERIVATIVES

A wide variety of codes, standards, guidelines and regulations are applicable to industrial education facilities. Designers planning new construction, retrofitting or equipment installations must comply with the National Building Code of Canada, the National Fire Code of Canada, and the Canadian Electrical Code. These codes in turn reference standards of the Canadian General Specifications Board, Canadian Standards Association, Underwriters' Laboratories Canada, National Fire Protection Association Inc., American Society for Testing and Materials, ASHRAE and others.

In addition, provincial legislation must be followed. The Public Health Act and Regulations and the Occupational Health and Safety Act and Regulations have wide

power to protect the health and safety of school children, teachers, clerical staff and custodians in schools.

The OHS Act and its regulations have developed gradually over many years, with new clauses and new regulations added to meet the changing needs of industry. The OHS regulations, therefore, contain sections now that are out of date, as is reflected by the total revision of the General Accident Prevention Regulation.

To date, the Alberta legislation offers general guidelines on the circumstances in which ventilation systems must be present, and the basic requirements for these systems. For specific details regarding number of air changes, capture velocities, and so on, we are referred to accepted codes of practice, such as ASHRAE or the American Conference of Governmental Industrial Hygienists. However, any ventilation system must maintain airborne concentrations of contaminants below the threshold levels laid out in the Chemical Hazards Regulations 8/82. Exact limits of tolerable noise levels have also been established.

To provide more specific guidance to school boards, teachers, and designers, the Alberta Occupational Hygiene Branch has prepared a booklet entitled Design Criteria For the Control of Health Hazards in Schools. The criteria set out does not have the force of legislation. However, the Director of Occupational Hygiene does have the power to order schools to alter any operation, or equipment if felt to be hazardous to the health and safety of the instructor.

The Alberta government seems to have spent much more time addressing the noise and ventilation problems in industrial arts facilities than have either the British Columbia or Ontario governments. Both provinces must follow the national codes, as well as certain ventilation requirements legislated in provincial statutes. British Columbia's Industrial Health and Safety Regulations 585/77 are quite thorough with the key to their ventilation standards being a lengthy table of permissible concentrations of chemical contaminants. This table is extremely similar to the Alberta Chemical Hazards Reg. 8/82.

SECTION 5

DESCRIPTION OF DESIGN STANDARDS AND GUIDELINES

The preceding section reviewed regulations in Alberta and other provinces. It included the Acts, Regulations, standards and guidelines that are accepted by professional groups in Alberta and elsewhere. The review concluded that a variety of codes, standards, regulations and guidelines were applicable to the design of industrial education facilities in Alberta and pertained to new construction, retrofitting and equipment installation. Examples would comprise the National Building Code of Canada, the National Fire Code of Canada and the Canadian Electrical Code. These codes reference standards of the Canadian General Specifications Board, the Canadian Standards Association, the Underwriters' Laboratories Canada, the National Fire Protection Association, Inc., the American Society for Testing and Materials and the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), as well as others.

A review of the legislation also invites a review of standards that are published by various agencies. Hence, a comparison of ventilation standards and guidelines is described in Table 5.1, and it includes both ventilation and noise, both being relevant to this research assignment.

5.1 MATRIX OF VENTILATION STANDARDS

A matrix has been prepared comparing the specific ventilation and noise requirements of the Design Criteria for the Control of Health Hazards in Schools booklet, the American Conference of Government Industrial Hygienists (ACGIH), ASHRAE, Alberta Occupational Health and Safety regulations, and B.C. Workers' Compensation regulations. In general the Design Criteria booklet provides specifications for a wider variety of areas than do any of the other organizations. Specifically, number of air

TABLE 5.1

COMPARATIVE VENTILATION STANDARDS

B.C. Workers Compensation Act Industrial Health and Safety Regulations	Occupational Health and Safety Act, Alberta	ASHRAE Guide 1978 Applications	Industrial Ventilation Manual - American Conference of Governmental Industrial Hygienists	Design Criteria for Control of Health Hazards in Schools	
					VENTILATION RATES
			–	12 PH	Photo Labs
Required (6)	Required (6)	10-15 cfm (5)	–	3 PH	Classrooms
			–	1 cfm/ft.^{2}	Volatile Substances Stores
		10-15 cfm (5)	–	3-6 PH	Woodwork Shops
			–	3-6 PH	Welding Shops
	3PH		–	3-6 PH	Motor Shops
			–	10 PH	Darkrooms
			–	10 PH	Printing Rooms
		30	–	–	Persons per 1,000 ft.^{2}
					AUTOMOTIVE SHOPS
100 cfm	100 cfm	–	100 cfm	105 cfm	Car Exhaust
200 cfm	200 cfm	–	–	210 cfm	Truck Exhaust
400 cfm	400 cfm	–	400 cfm	420 cfm	Diesel Trucks
	–	–	–	50 cfm	Small Motors
Required (6)	Required (6)	–	–	1 cfm/ft.^{2} (1)	Repair Pits
	–	–	2,000 fpm	–	Duct Main Size
					SPRAY PAINT BOOTHS
50 fpm (2)	50 ft.mm (9)		–	50 cfm^3/ft.^{2}	Large Booth
100 fpm (2)			1-3000 (4)	100 cfm/ft.^{2} (3)	Small Booth
			–	100 fpm	Small Booth Capture Velocity
					WELDING AND SOLDERING
Required (6)	–		–	100 fpm	Local Capture Velocity
	2,000 cfm	–	–	2,000 cfm (5)	Per Arc Welding Set
			1-3,000 cfm	–	Duct Velocity
			1,000 cfm	–	Rod Ø cfm welder – 5/32
			1,500 cfm	–	Rod Ø cfm welder – 3/16
			3,500 cfm	–	Rod Ø cfm welder – 1/4
			4,500 cfm	–	Rod Ø cfm welder – 3/8
			800 cfm	–	Open Area 1 lb. of Rod
			1,600 cfm	–	Closed Area 1 lb. of Rod
	200 fpm (7)				Metalizing

NOTES:

(1) Mount 1-0 above pit floor
(2) Per cross sectional area of booth
(3) Mild steel welding only
(4) Duct velocity
(5) Ventilation rate per person
(6) Ventilation required but no rates specified
(7) Local system required hood
(8) Minimum face velocity on any exhaust hood type
(9) Velocity for full cross-section area, based on pick-up

TABLE 5.1 (cont.)

B.C. Workers Compensation Act Industrial Health and Safety Regulations	Occupational Health and Safety Act, Alberta	ASHRAE Guide 1978 Applications	Industrial Ventilation Manual - American Conference of Governmental Industrial Hygienists	Design Criteria for Control of Health Hazards in Schools	
Required (6)					**FOUNDRY OPERATIONS**
			—	100 fpm	Capture Velocities
			1-3,500 fpm	--	Duct Velocity
			3,500 fpm	—	Metal Lathe Duct Velocity
					FINE ARTS
				100 fpm	Silk Screen Capture Velocity Hood
					GRAPHICS
					Canopy Over Print Machine
				50 fpm	Capture Velocity
					CERAMICS
					Sand Mixing Local Hood
				100 fpm	Capture Velocity
					Kiln Hood
				50 fpm	Capture Velocity
					PLASTICS
					Exhaust Canopy
				100 fpm	Capture Velocity
					PRINTING
					Spirit Duplicator Hoods
	Required (5)			50 fpm	Capture Velocity
					NOISE
16hr-87dBa	16 hrs	—	—	16 hrs	80 dBA
8hr-90dBA	8 hrs (10)	—	—	8 hrs	85 dBA
4hr-93dBA	4 hrs (10)	—	—	4 hrs	90 dBA
2hr-96dBA	2 hrs (9)	—	—	2 hrs	95 dBA
1hr-99dBA	1 hr (11)	—	—	1 hr	100 dBA
1/2hr-102dBA	1/2 hr (11)	—	—	1/2 hr	105 dBA
1/4hr-105dBA	1/4 hr (12)	—	—	1/4 hr	110 dBA
0hr-over 105dBA	1/8 hr (12)	—	—	1/8 hr	115 dBA
	—	35-45	—	—	NC Vocational Shops

NOTES:

(9) Protectors required Type C
(10) Protectors required Type B
(12) Protectors required Type A

TABLE 5.1 (cont.)

B.C. Workers Compensation Act Industrial Health and Safety Regulations	Occupational Health and Safety Act, Alberta	ASHRAE Guide 1978 Applications	Industrial Ventilation Manual - American Conference of Governmental Industrial Hygienists	Design Criteria for Control of Health Hazards in Schools	
					WOODWORK SHOPS
Required (5)	Required (6)		—	4,000 fpm	Transport Velocities
			350 cfm 3,500 fpm	—	Disc Sand
			750 cfm 3,500 fpm (9)	—	Band Saw
			3,500 fpm 350 cfm (10)	—	Table Saw
			500 cfm 3,500 fpm	—	Radial Saw
			350 cfm 3,500 fpm	—	Lathe
			3-1400 fpm	—	Floor Sweep
					LABORATORIES
80-100 fpm (8)					Fume Hood
125-150 fpm (8)					Fume Hood - Carcinogenic Substances

NOTES:

(5) Blade up to 2" wide
(10) Blade up to 16" Ø

Source: Cheriton Engineering Ltd.

changes per hour and capture velocities for local exhaust hoods in facilities for fine arts, photography, printing, graphics, ceramics and plastics are stated in the Design Criteria guidelines alone. In certain areas, such as automotives, spray painting and welding, the Alberta OHS regulations, British Columbia regulations, and Design Criteria guidelines provide almost identical figures. Details regarding design features that are acceptable to the Alberta OHS Branch Division available for perusal in their draft copy Woodworking Exhaust Ventilation Guidelines for Schools.

5.2 LITERATURE REVIEW

An extensive on-line citation search was conducted in a two-step approach. The first phase was conducted in the early stages of the assignment and concentrated on general standards, issuing agencies, and ventilation applications to industrial education to mention the general themes. A void of subject-specific information was encountered. The data base management systems and data bases are noted in Appendix O, Volume 3. About half a dozen citations were considered to be marginally useful, however, none of them were available through the University of Alberta, corporate libraries, provincial government libraries or the Alberta Environmental Centre Library in Vegreville, Alberta. Because they were considered marginal in utility, a retrieval beyond the province was considered unwarranted.

Commensurate with the on-line search, a manual search consisting of telephone interviews within and external to Alberta was conducted, and it appeared to suggest two results. First, any reference to the setting of standards pointed to publications that tended to support rather than criticize existing standards and guidelines; and second, case study information was discussed in materials that were denoted as copyright materials. They were American Conference of Governmental Industrial Hygienists, Inc. (ACGIH) materials, and hence have not been reproduced in this report.

When it was learned through testing that wood dust and noise were the chief problems that were present in the industrial education shops, a second on-line citation search was conducted. This search used a finer assortment of key words and concentrated on

woods and wood dusts in industrial and education facility contexts. Again, a virtual blank was drawn, and any citations that appeared within the scope proved not to be useful when an annotated citation was called up.

One main document which has proven useful was published by the International Labour Office of Geneva, Switzerland. A general discussion regarding occupational exposure limits for airborne toxic substances, including particulates, is provided in Appendix A of this volume.

In summary, it appears that several industrially advanced nations are concerned about workers' safety and health and have published standards and guidelines regarding airborne toxic substances. Depending upon the nation, some standards are rigidly enforced by legislation, others are noted as tolerable values that should be heeded by designers. Regardless of the standard mentioned and the issuing agency, it appears that one cannot denote that there is an absolute guarantee of a safe limit, but that one should refer to the values as exposure limits that are essential guides to the control of occupational risks. Further, it is stated that the standards are changing, generally to more stringent values as more research is conducted. Further, it is important to note that exposure tolerance values are subject to ambient conditions, i.e. atmospheric pressure, temperature and the presence of more than one substance; additionally, they refer to pure substances.

The publication also discusses definitions of the various terms that are used to define concentration of airborne contaminants, and they too are described in Appendix A.

5.3 OCCUPATIONAL EXPOSURE LIMITS FOR WOOD DUST

To date, the Alberta legislation offers guidelines concerning the circumstances in which ventilation systems must be present, and the basic requirements for the ventilation systems.

For specific details, the designer is directed to reference documents that provide prescriptive numbers of air changes per hour, linear capture velocities, duct velocities

and filtration standards in the case of air quality. The underlying expression is the removal of airborne contaminants and dust, or expressed in other terms, the maintenance of airborne contaminants and dust below specified exposure levels. The occupational exposure limits (OELs) are noted as limit values in Alberta's Chemical Hazards Regulations (8/82). The degree of air pollution and density, expressed in dimensions of parts per million (ppm) or milligrams per cubic meter (mg/m^3) is the working value. Definitions and OELs for wood dusts are described in Table 5.2.

They are aggregate dust levels and are not species specific, other than allergenic and non-allergenic genres.

A draft copy publication by the OHS branch, Working Exhaust Ventilation Guidelines for Schools is suggested as source material for designers of ventilation equipment of industrial education facilities. One table denotes poisonous and strongly allergenic woods and its information is contained in Table 5.3.

5.4 NOISE EXPOSURE LIMITS

It appears from Table 5.1 that two agencies are concerned with noise limits. They are ASHRAE and the National Institute of Occupational Safety and Health (NIOSH), part of the U.S. Department of Health, Education and Welfare. The OHS branch of Alberta Workers' Health, Safety and Compensation uses NIOSH standards for noise exposure.

Exposure limits for noise, or those values expressed in the dimensions of decibels on the A scale for a given duration are recommended as being safe to the point where permanent impairment to hearing will not be incurred. Recommended noise standards for vocational shops are noted by ASHRAE and are based upon the average noise that is acceptable for normal speech intelligibility, at a given distance between source and listener. The implication is that ASHRAE is concerned with communications capabilities which are within accepted tolerable limits, while NIOSH prescribes upper limits that are considered tolerable to the individual, i.e. not to exceed values that may impair hearing.

TABLE 5.2

EXPOSURE LIMITS TO WOOD DUST

Substance	PRESCRIBED OCCUPATIONAL EXPOSURE LIMITS					
	8 hour		15 minute		Ceiling	
	ppm	mg/m^3	ppm	mg/m^3	ppm	mg/m^3
Non-Allergenic Wood Dust	--	5	--	10	--	--
Allergenic Wood Dust	--	2.5	--	5	--	--

Definitions:

a) An "8 hour OEL" means the time-weighted average concentration of an airborne substance for an 8 hour period;

b) a "15 minute OEL" means the time-weighted average concentration of an airborne substance for a 15 minute period;

c) a "ceiling OEL" means the maximum concentration of an airborne substance;

d) "ppm" means parts of a vapour or gas by volume per million parts of contaminated air by volume; and

e) "mg/m^3" means milligrams of substance per cubic meter of air measured at standard conditions of 25°C and 100 kiloPascals.

Source: Occupational Health and Safety Act
Chemical Hazards Regulation, Alberta Regulations (8/82)

TABLE 5.3

SOME COMMON POISONOUS AND STRONGLY ALLERGENIC WOOD VARIETIES

Common Name	Botanical Name	Main Habitat
Box	Buxus sempervirens	Europe (esp. southern)
Boxwood (South Africa)	Gonoima Kamassii	South Africa
Calaba	Calophyllum brasiliense	Brazil
Cashew	Anacardium occidentale	Indonesia, India
French Ash	Cytisus laburnum	Europe
Illupi longifolia	---	India
Illupi latifolia	---	India
Iroko	Chlorophora excelsa	Africa (tropical)
Kino	Pterocarpus	Africa (tropical), Indonesia
Mahogany	Swietenia mahagoni	Cuba, Hispaniola
Makore	Mimusops	Africa (tropical), South America
Mansonia	Mansonia altissima	West Africa (tropical)
Ouebracho	Aspidosperma	South America (tropical)
Rauwolfia Pentaphylla	--- ---	South America
Red Cedar (Western or West African)	Thuja Plicata Guarea thompsonii & Guarea cedrata	Western West Africa
Rosewood	Dalbergia	India, Africa (tropical), Brazil
Satinwood	Chloroxylon swietenia	India, Ceylon
Teak	Tectona grandis	Asia (tropical)
Tecoma	---	South America, India
Yew	Taxus baccata	Asia, Europe
Zanthoxylon	Fagara flava	India

Table 5.3 continued on following page.

Table 5.3 (continued)

Note: Wood varieties may be classified under three categories on the basis of their biological effects on human beings:

a) poisonous or allergenic
b) biologically active
c) biologically inactive, or nearly so

The above is a partial list only. For those woods that are not included in this list, but may be of poisonous or strongly allergenic nature, they shall be determined, defined and interpreted at the discretion of Occupational Hygiene Branch from time to time.

This list should be referred to and be used as guidelines only, and should, in no way whatsoever, be interpreted as a document of Laws, Regulations, etc. of some form.

Source: Occupational Health and Safety
Woodworking Exhaust Ventilation Guidelines for Schools, Draft copy

SECTION 6

CONCLUSIONS

6.1 SUMMATION OF TECHNICAL TEST RESULTS

Detailed results of the testing performed on the 20 selected Industrial Arts Laboratories are contained in Volume 2, Technical Report. The following major defects were noted in a large number of the test areas:

(i) high dust concentration (higher than OHS recommendations);

(ii) high noise level (higher than OHS recommendations); and

(iii) insufficient make-up air (resulting in negative pressures within the laboratory area).

The following undesirable items were present in a large number of laboratory areas:

(i) large dust collection machinery with fan horsepower ranging from 10 to 25. There was no evidence that a larger dust removal system caused a lower dust level in the student area;

(ii) large dust collection hoods, with very low face velocity, resulting in poor dust capturing ability;

(iii) welding and other hot processes such as soldering and foundry, with overhead fume hoods, which encouraged the movement of the fumes past the face of the student;

(iv) plastic and ceramic areas which had no or very ineffective fume removal devices;

(v) darkroom developing areas have air changes as required by OHS, but still had perceivable chemical odours; and

(vi) fan systems, while operating, did not generate sufficient air velocity to achieve the desired results.

6.2 SUMMATION OF PERCEPTION SURVEY AND OTHER OBSERVATIONS

The foregoing section has discussed a potential engineering solution that is considered to be an improvement to the existing circumstances of the 20 sample schools. There are other considerations that are eligible to contribute to the resolution of the issues with which school boards and designers must face regarding dust collection and ventilation in industrial education facilities.

6.2.1 Personal Safety Equipment

The Industrial Education Ventilation Study Survey, conducted by Stanley Associates Engineering Ltd., enquired about instructors' perceptions of use of personal safety equipment by both instructors and students. The instructors stated that in 82 percent of the cases they use eye protection all of the time, although one must note that they use it as they require it. Fourteen percent indicated that they use eye protection occasionally. They noted that it was their perception that it was the same percentage for students regarding the use of eye protection all of the time, but in only ten percent of the cases were students perceived to use it occasionally.

The perceived use of ear protection is quite the opposite to that of the eyes. The instructors noted that they use hearing protective devices either "seldom" or "never" in 93 percent of all cases, and only 7 percent "occasionally." The values for students' use of such equipment total 93 percent "seldom" or "never," and only 7 percent "occasionally."

Additional protective clothing such as aprons, lab coats, gloves, hair protection, shoes, welding screens, guards on equipment, face masks and breathing filter masks were noted sporadically in eight of the test schools. The greatest attention to other protective devices appears to be given in the rural high schools' shops; Ardrossan, Thorsby and Lamont.

6.2.2 Issues Related to Classroom Safety

There are three issues that are related to the theme of personal protection. The first one is the learning experience gained within the classroom. An appreciation of safety hazards in the classroom and their reduction due to personal protection lead to a recognition of safety hazards during a vocation and consequently attention may be paid to their mitigation within a potentially greater risk environment. The second is an appreciation for health risks in an educational environment. Clearly, there are various types of safety equipment, regardless of kind and hence they provide protection against different forms of hazards, e.g. air filters. Should the student be aware of the reasons for using different varieties of personal protection equipment, he may transfer this knowledge into one of greater curiosity and hence resolution in working environments beyond the classroom. The third issue is one of motivation, i.e. creating the set of circumstances in the classroom in which all students and all instructors will wear all necessary safety equipment when needed all of the time.

6.2.3 Operation of Existing Dust Collection Equipment

A great proportion of the new dust collection systems that were observed in the 20 sample schools had excessively caked filters which reduced air volumes. This would suggest the cleaning and maintenance beyond using the shake-down cycle is not occurring.

6.2.4 Review of Curriculum

The magnitude of the ventilation problem is related to the curriculum content of industrial education for junior and senior high schools. It was apparent from the tests

and observations that certain pieces of woodworking equipment, predominantly sanders and lathes and the powdered materials in the ceramics area created respirable dust and large quantities of nuisance dust.

Generally, one might assume that given any dust problem, an ideal engineering solution might eventually be derived should the issue be one of dust collection. Costs must be considered in this approach, particularly if the potential scope of the problem is 400 schools in Alberta in which industrial education is taught.

It is apparent that the engineering design is an expensive solution to a dependent issue. The root of the problem, that is the independent issue, is the scope of content of the industrial education curriculum and its translation into shop projects.

Should the objective of the curriculum and hence shop projects be one of introducing various processes and equipment to the student, then the matter may be considered in terms of the following parameters:

(i) the types of machines with which student interaction is necessary;
(ii) the magnitude, i.e. duration of the interaction; and
(iii) the derivative of the interaction.

Clearly, if certain high dust creating machines must be used, can the projects be arranged to minimize the duration of interaction? Further, the derivatives of interactions would include the utility of the machines and their impact when they are in contact with construction materials. Another derivative would be the recognition of potential health hazards that are inherent to the use of the equipment when the operator is not using protective equipment.

6.2.5 Hazardous Materials

Research by health and safety conscious agencies world-wide is identifying hazardous materials. Allergenic woods, for example, have been identified and a partial list is contained in this report. It appears that when hazardous materials are used, the

degree of elaboration of equipment to remove them and their byproducts increase, commensurately, so does the cost.

6.2.6 Computer Storage

Microcomputers were stored in the main shop area in a great deal of those industrial education shops that were tested. This may be a dysfunctional activity due to dust that can clog the disc drives and other airborne substances that may corrode the memory circuits.

6.3 RESPONSES TO THE RESEARCH DECISION POINTS

Research questions that relate to specific issues are defined as research decision points. They are subsets of general issues that have been noted and they can also be a link between issues. Responses to each research decision point are noted in Table 6.1.

TABLE 6.1

RESPONSES TO THE RESEARCH DECISIONS POINTS

RESEARCH DECISION POINTS	RESPONSES	REFERENCE TO TEX
(i) What are the existing OHS ventilation standards that can be applied to industrial education to maintain the integrity of the learning environment; that is, is the setting safe for interaction between student and equipment and condusive to interaction between instructor and students?	The Alberta OHS standards relative to dust extraction and noise in the industrial education shops are applicable.	Section 5, Volume I
(ii) What alternate ways, as compared to present methods, are available to hook up equipment to ventilation and dust extraction systems while maintaining the validity of the curriculum for the student? (iii) Can OHS ventilation regulations be developed to permit the use of alternate ventilation and dust extraction systems in the schools? (iv) What special design considerations must be addressed to examine the use of alternate ventilation and dust extraction systems for schools?	Drawing M-1 contains some improvement to the OHS type hood for lathes. An alternate dust duct system has been proposed in this report as well as specific recommendations regarding types of hoods to be employed in specific areas (ie. slotted hood over the sink in photographic areas). The special consideration which must be applied to the design is to select proper monitoring and/or signalling devices to indicate to the instructor that the protective system is operating, or at the very least, that the system has been turned on. It is imperative that a variable volume make-up air supply system be installed due to the large number of small exhaust systems with varible operating schedules. This unit may be shut-down during periods when the laboratory is not in operation for energy conservation programs.	Section 7, Volume I
(v) What industrial education processes require ventilation, dust extraction or control?	All activities that create dust, contaminants, smoke and odours in the industrial education shop require review. Solutions may imply direct venting, such as exhausting small engine outputs, soldering and welding derivatives or filtration such as wood dust.	Section 7, Volume I
(vi) What commercial ventilation and dust extraction systems are available that would meet the needs of the educational setting?	Apart from those that are already in place in the 20 sample schools, suppliers of components were contacted and they are listed in Appendix P of Technical Appendix volume. However, each application is different and requires custom design.	Appendix P, Volume
(vii) What is the optimum type of ventilation and dust extraction system for industrial education laboratories?	An optimum system must meet the requirements of OHS standards, have low cost and be readily maintainable. Based on the observations in the 20 sample schools, there was not an ideal design which fully met the three targets above. It is apparent that each case must be treated individually due to the large number of variables present in each school.	Section 7, Volume I

Table 6.1 (continued)

RESEARCH DECISION POINTS	RESPONSES	REFERENCE TO TEXT
iii) How can the problems that are created by the different locations of ventilation and dust extraction systems in industrial education shops be minimized?	Noise is the main derivative if the dust extraction unit is not separated from the workshop. Smaller, special exhaust units were not perceived to contribute significantly to the noise problems. They should be located at the perimeter of the shop and fresh air should be introduced in the central areas. This will prevent odours and contaminants from being directed toward students and instructors.	Section 7, Volume I
x) What additional standards or regulations are applied, or should be applied, to industrial education shops?	The Alberta context has been addressed in Section 4 of this report.	Section 4, Volume I
) What is the chronologic development and source of all relevant standards that are applied to industrial education shops and what were the original standards?	The major advances in environmental standards occurred after World War II. Regulations that are relevant to Alberta are noted in this report. It appears that most industrial nations are concerned with the provision of a "limited risk to health" philosophy and consequently are amending the values, i.e. standards, frequently.	Section 4, Volume I Appendix A, Volume I
xi) Are there legal implications or processes currently in progress with respect to ventilation and dust extraction equipment in any school throughout Alberta?	All members of the Steering Committee stated that they were not aware of any litigation in progress or under consideration, but acknowledged that remedial measures were underway in one test school for the purpose of retaining an instructor.	Meeting Nos. 1 and 2
iii) How have post-secondary education facilities, e.g. NAIT and SAIT, coped with OHS ventilation standards, and to what degree has their progress been satisfactory? What information can be utilized from their situation for the purpose of providing an adequately healthy and safe environment in junior/senior high schools?	Although contact informally was made with NAIT, a tour was not conducted. It was believed that the scale of activities compared to junior high schools may have been overwhelming and, hence may not have contributed much to this assignment.	–
iii) What Workers' Compensation measures are applicable to industrial education facilities?	Instructors, and not the students, are the subject matter of the Workers' Compensation measures.	Section 4, Volume I

Table 6.1 (continued)

RESEARCH DECISION POINTS	RESPONSES	REFERENCE TO TEXT
(xiv) To what degree has previous research been carried out prior to the request for initial proposal written by the Steering Committee that was concerned with this matter?	The only source of information about introductory research was OHS field observations, although a full set of notes regarding the status of the 20 sample schools was not made available to the study team.	—
(xv) What impacts can be identified as feasible and realistic through potential future measures undertaken by school boards and Alberta Education via the School Buildings Branch in either altering standards or retrofitting ventilation and dust extraction equipment within the 20 sample schools that will be addressed during the course of this assignment? Indeed, what will be the economic spin-off and impact from the 20 schools to the residual 400 schools noted above? Are there opportunities for extraordinary and sophisticated electronic equipment to be used to mitigate the dilemmas of teaching in noise-burdened environments? Is there an opportunity for utilizing efficient dust monitoring systems to control the degree of filtering and processing of fresh air?	As discussed in this report, there are several recommendations that the school boards and Alberta Education will want to implement. They are aimed at retrofit measures, rather than a reduction of standards. Because the 400 residual schools were not evaluated, the economic impact of retrofit cannot be estimated accurately. The general estimate of cost by Cheriton Engineering Ltd. for the prototypical concept is about $75,000. The system does contain ideas regarding monitoring filters. Each board will want to assess the merits of retrofitting industrial education facilities with adequate dust extraction equipment facilities and their utilization. Noise can be reduced by two measures. Generally, the noise creating machinery, such as the dust collection unit, can be isolated in its own room, and for that matter the woodworking component of the shop can be located in a separate room, as noted in Drawing M-1. Personal safety equipment such as noise abating ear plugs can assist the instructors and students to reduce noise to below the hazardous level.	Section 7, Volume 1
(xvi) To what degree will the age, i.e. ultimate phasing out of school buildings and hence their equipment, play in the provision of alterations throughout our test schools and the residual 400 schools noted above?	School age was not a parameter in the 20 test schools; however, consideration regarding the future of student enrolments should be given regarding the continuation of industrial education in each school.	Steering Committee Meetin

Table 6.1 (continued)

RESEARCH DECISION POINTS	RESPONSES	REFERENCE TO TEXT
(xvii) To what degree would the tests in the 20 sample schools reveal reduced teaching efficiency and reduced equipment needs in industrial education shops?	The results of the tests in the 20 schools indicated that the existing dust collection systems generally were inadequate and hence a reduction in their accoutrements may not be a solution. The noise tests indicated that in several cases, given certain circumstances, speech intelligibility and hence teaching efficiency, was restricted.	Volume 2, Technical Report Volume 3, Technical Appendices
	Future measures to reduce costs but not effectiveness would be to investigate the transport velocities that are necessary for the exhaust system to fulfill its function. Present standards are based on industrial circumstances. With fine dusts being more prevalent than large pieces of lumber shavings, does duct velocity have to be equivalent to industrial requirements? The reduced velocity system may be applicable with the suggested improvements in hoods. This can only be determined by monitoring the effectiveness of the systems recommended by Cheriton Engineering Ltd., contained in this report.	Section 7, Volume 1
(xvii) What measures are being undertaken by the department of education in other Canadian provinces, e.g. British Columbia and Ontario?	Contacts with provincial government and municipal school jurisdictions revealed accepted standards and regulations, but it appeared that there was not a wealth of historic literature regarding ventilating industrial education shops.	Section 4, Volume 1

Source: Stanley Associates Engineering Ltd.
Cheriton Engineering Ltd.

SECTION 7

RECOMMENDATIONS

7.1 SYNOPSIS OF RECOMMENDATIONS

Nineteen recommendations are contained in this report. They are summarized in the following way:

(i) The dust collection system size is to be based on the number of machines in use simultaneously.

(ii) Woodworking power tools are to be segregated to a separate room.

(iii) Other pollution creating processes are to be vented and are to be located on the perimeter of the laboratory.

(iv) A separate fresh air supply is to be provided for make-up air.

(v) Toxic pollutants, such as paint and engine exhaust, should be located in separate rooms with exhaust facilities.

(vi) Collection hoods are to be of a high velocity with a small face area design.

(vii) Wood lathes are to have sliding hoods.

(viii) Darkrooms are to have slot exhausts over sink areas.

(ix) Ceramic work zones should have exhaust cubicles.

(x) The laboratory area is to be maintained at slightly negative pressure to the rest of the school.

(xi) All appropriate forms of safety equipment should be worn by students and instructors all of the time in the industrial education shop.

(xii) Frequent cleaning and maintenance of dust collection systems should be arranged.

(xiii) The curriculum of industrial education and its translation into shop projects should be reviewed in order to reduce the period of interaction that the students and instructors have with activities and shop equipment which create high levels of dust.

(xiv) Regular reviews of what constitutes a hazardous and allergenic material should be undertaken for the purpose of removing the material from the industrial education shop.

(xv) Micro-computers should be removed from the industrial education shop and its environment, or should be placed in a room that is not influenced by dust and contaminants.

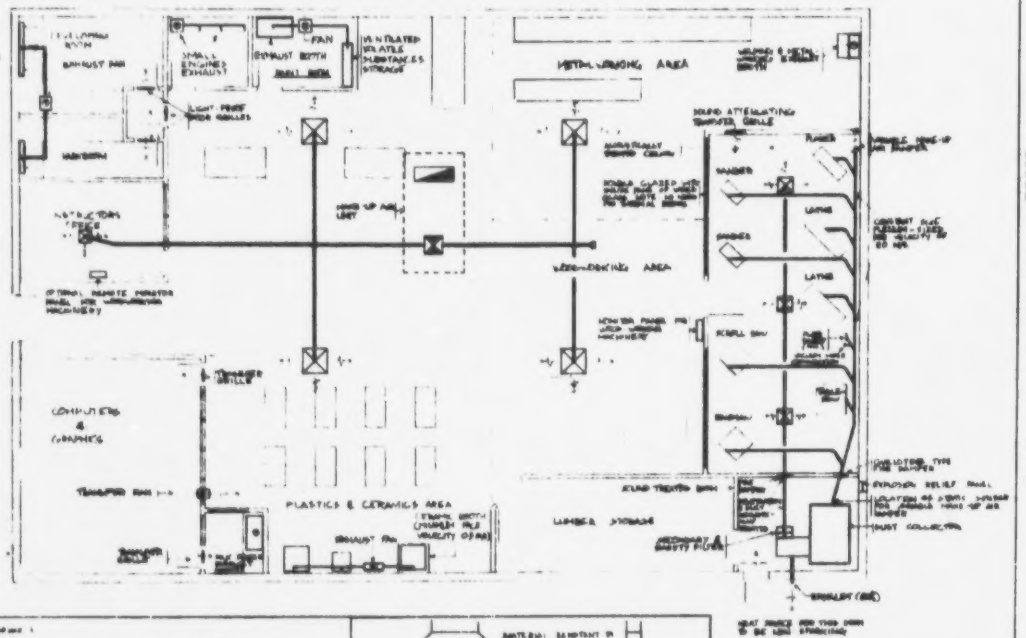
(xvi) Interim protective measures, i.e. personal protection, should be undertaken in industrial education shops that do not have adequate main dust collection and ancilliary ventilation equipment.

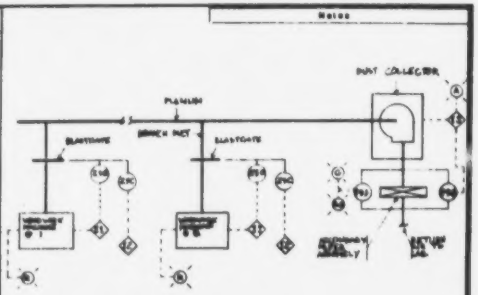
(xvii) Maintain a technical testing program in the 20 sample schools and expand it to the residual 400 schools that have industrial education shops throughout the province.

(xviii) Regularly review standards' issuing agencies for alterations of standards and substances on their toxic substances lists.

(xix) Continue research on the mechanical design of the prototypical engineering system noted in Drawing M-1.

NOTE: THIS DIAGRAM IS FOR REPORT PURPOSES AND SHOULD ONLY BE VIEWED AS AN INDICATION OF DESIGN APPROACH.





(BG) LIMIT SWITCH WHICH ACTUATES IN FULLY OPEN BLASTGATE POSITION

(I) INTERLOCK TO ENABLE MACHINE OPERATION WHEN BLASTGATE IS FULLY OPEN

(BC) LIMIT SWITCH WHICH ACTUATES IN FULLY CLOSED BLASTGATE POSITION

(P) INTERLOCK TO PERMIT OPERATION OF UP TO ANY 4 MACHINES

(R) PILOT LIGHT TO INDICATE THAT MACHINE IS IN OPERATION

(PD) PRESSURE DIFFERENTIAL SWITCH

(M) INTERLOCK WITH MANUAL RESET TO SHUT DOWN DUST COLLECTOR AND ALL MACHINES

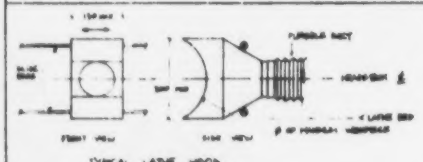
(A) PILOT LIGHT TO INDICATE FILTER IS BLOCKED AND SYSTEM POWER IS CUT

(G) PILOT LIGHT TO INDICATE FILTER IS CLEAN

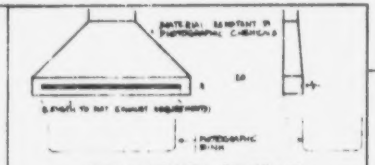
(R) PILOT LIGHT TO INDICATE FILTER IS DIRTY (90% OF FULL CAPACITY)

NOTE: A KEYSWITCH IN THE INSTRUCTORS OFFICE CONTROLS POWER TO THE DUST COLLECTOR & ALL MACHINES. OPENING ANY BLASTGATE STARTS THE DUST COLLECTOR CLOSING THE LAST BLASTGATE STARTS A TIME-DELAY SWITCH FOR 3 MINUTES WHICH OPERATES THE DUST COLLECTOR AND OPENS THE MAKE UP AIR DAMPERS SO THAT THE PLENUM IS SWEPT OF ANY DUST THAT MAY HAVE SETTLED DUE TO TEMPORARY LOW VELOCITIES IN SOME PARTS OF THE PLENUM

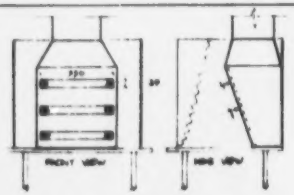
DUST COLLECTOR CONTROL SCHEMATIC



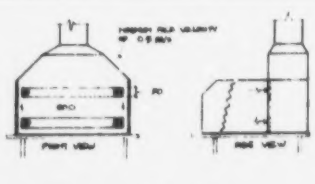
TYPICAL LATHE HOOD (NTS)



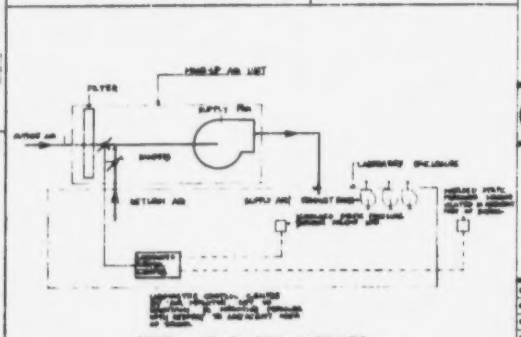
TYPICAL DARKROOM EXHAUST SINK (NTS)



TYPICAL WELDING & METALWORKING EXHAUST BOOTH (NTS)



TYPICAL SILKSCREEN BOOTH (NTS)



GENERAL VENTILATION SCHEMATIC

No	Revisions and issues	Date	By

CHERITON ENGINEERING LTD.

PROTOTYPICAL VENTILATION LAYOUT FOR JUNIOR HIGH SCHOOL INDUSTRIAL ARTS LABORATORY

drawn	J.R.	date	11-Oct-83
design	J.R.	sheet	of
checked	D.P.	job no.	M 424
scale		drawing no.	M 1
		revision	

DO NOT USE AS A WORKING DRAWING

7.2 MECHANICAL DESIGN RECOMMENDATIONS

7.2.1 General

A dust collection system that has universal applications is an ideal for which to strive. System components can be supplied by various sources, as noted in Appendix P, Volume 3, however, each total system will require system design. A sketch design of a proto-typical laboratory is noted in Drawing M-1.

The design philosophy is to mitigate the OHS infringements and reduce the undesirable features of the majority of Industrial Arts Laboratories tested.

The "proto-typical" design makes the assumption that the Province of Alberta, Occupational Health and Safety Standards for Hazardous Chemicals and Dust retained in the working atmosphere are not exceeded. While the suggestion that the students are exposed only for a few hours per week and, therefore, the standards can be pro-rated for the short exposure time, the instructor is exposed for most of the teaching day. A counter-argument for not pro-rating for students is that these young men and women are at an age where growth is still taking place, and the toxic effect of hazardous chemicals on growth and development may be greater than that of mature adults.

This study accepts the OHS air concentration standards. These are reviewed by OHS personnel on an approximate ten percent per annum basis, therefore, no standard is more than ten years old, and revisions are made with the most recent technological evidence available.

However, since the recommended methods to maintain hazards at or below published values are for industrial plants, the proposed methods for achieving the desired results for the school laboratories represent some cost saving, on the assumption that supervision standards and motivation will be higher in the teaching environment than one can expect from industry. A number of electrical/electronic safeguards are recommended to assist the instructor in ensuring proper operation of both the power tools and the dust collection equipment.

7.2.2 Rationale for Prototypical Laboratory Layout

The prototypical drawing, M-1, incorporates the suggestions to mitigate problems found in the laboratories surveyed. They are the following considerations:

(i) A self-contained fresh air supply is required. This should vary the amount of outside air brought into the laboratory to maintain a slight negative pressure within the laboratory space. If the fresh air make-up unit is to be used as a source of heat for the laboratory, controls should be incorporated to ensure that each function can operate independently.

(ii) The distribution of make-up air is from the central area to exhausts located at the outer perimeter. This will reduce pollution of the incoming air by fumes and vapours not removed by exhaust equipment.

(iii) Dust and noise producing equipment, such as woodworking machinery, is placed at one end of the laboratory and is isolated by glazing and walls. The dust extraction machinery is placed in a remote corner, in a further attempt to isolate noise.

(iv) Dust extraction equipment is "down-sized" to supply exhaust capacity for the largest number of machines likely to be used simultaneously rather than all machines installed. This will further reduce noise and capital cost.

(v) Darkrooms, which are under a slight vacuum (to prevent odours and fumes contaminating the general laboratory area), may induce small metal, ceramic or plastic particles. The small particles may adhere to film and/or photographic equipment which is extremely sensitive to this type of contamination. Therefore, plastic, ceramic, metal working and welding areas are placed as far as possible from the darkroom.

(vi) Fumes, with a high degree of toxicity, such as engine exhaust or paint fumes, are generated in an enclosed area and removed directly by exhaust fans.

(vii) Areas requiring sound isolation are enclosed with glazed barriers, such as the instructor's office and the graphics room.

7.2.3 Woodworking Power Tools

The creation of the high wood dust residual levels is due mainly to the sawdust and shavings from powered tools. While many of the schools had dust collection systems, the performance was above OHS maximums. The microscopic size of the respiratory dust allowed it to remain suspended for long periods of time and diffuse throughout the laboratory. It is therefore recommended that all fixed woodworking power tools be placed in an enclosed area against the furthest wall. The enclosure would have an acoustically treated ceiling and partition walls. Double glazing would allow the instructor to supervise the students. Wire reinforced glass should be used on the inner pane to reduce the hazard of breaking glass.

The major deviation from past practice is to size the dust collection machinery on the basis of the maximum number of machines to be used simltaneously, rather than the number installed. It was observed during the 20 school survey generally no more than 3 machines were being used at one time, therefore, the limitation should have minimal effect upon the curriculum. The reduced capacity of the dust collection machinery will reduce both cost and noise levels. While no dust sampling was performed on the recirculated air, the high ambient dust level, even with elaborate hoods and duct work, would indicate that more filtration is necessary. It is, therefore, proposed that a secondary high efficiency particle arrestor (H.E.P.A.) filter bank be installed in series with the primary unit. An alarm device, based on H.E.P.A. filter pressure drop would indicate large amounts of dust leaving the primary mechanism and settling in the secondary unit. This would reveal a lack of maintenance or a defective primary unit.

The negative aspect of down sizing the primary unit is that more sophisticated design of the dust collection ductwork is necessary, and that automatic "bleed" devices are required to ensure that minimum dust transport velocities are maintained within the ductwork regardless of the number and sequence of machine operation. The minimum size of the dust collection system will be based on the simultaneous operation of the largest power tools. A fixed percentage (say 20 percent) of the exhausted air is

discharged to the outside, and this deficiency is made up by fresh air in order to reduce the level of any air-borne chemicals which may be present in the woods that are being worked.

7.2.4 Welding and Soldering Fume Removal

Observation and tests at a number of schools demonstrated the effectiveness of the slotted fume removal hood when compared to the canopy type. This type of hood is also recommended for silk screen cleaning, and the use of side panels is encouraged to ensure that the maximum amount of cleaning fluid fumes is captured.

7.2.5 Photographic Developing Room

The slot type hood over the sink was found to remove odours more effectively than the ceiling type exhaust grill.

7.2.6 Paint Booth

Commercially available paint booths with impingment type filters perform in a satisfactory manner when installed and maintained in accordance with manufacturers instructions. No change is recommended in this area.

7.2.7 Small Engine Exhaust

Present exhausting methods are satisfactory, but venturi or induction type fans seem superfluous since the engine exhaust is diluted by the clearance between the inlet duct, usually 3 inches and the exhaust pipe, 1½ inches. A standard centrifugal fan would be satisfactory.

7.2.8 Make-Up Air

Due to the variable amount of exhausting, the use of a ventilation system that is interconnected with the main school system for the purpose of providing make-up air

is unsatisfactory. If the ventilating system also provides heating, the problem is compounded.

A separate make-up system which provides room temperature air, and maintains a slight negative pressure in the laboratory is the recommended procedure.

7.2.9 Plastics (Heating and Forming)

Most appliances used in this area have connections for a ventilating system. These should be connected together by means of a manifold and exhausted to the outside. A large indicating light should be used to show the instructor that the fan has been energized.

7.2.10 Ceramics Areas

Mixing and grinding areas should have a shielded area on three sides, with the student performing his tasks on the open face. A deep canopy can be used to capture the fumes and exhaust to the outside.

7.2.11 Graphics and Classroom Areas

Sufficient ventilation shall be provided to ensure fresh air for the students. Local exhaust need be provided for intense odour or fume producing equipment. Some duplicating fluids may readily vapourize, and these should be removed to the outdoors by a small self-contained system.

7.2.12 Drawing Notes

The "proto-typical" drawing is a guide only, and should not be viewed as the "ideal" laboratory. It is not to scale, and the equipment suggested has been limited to Junior High Industrial Arts Laboratories. The layout and ventilation has been discussed with OHS and they are aware of the deviations with respect to dust collection equipment sizing.

7.2.13 Cost Feasibility

Compared to the equipment found installed in the newer laboratories, the recommended ventilation equipment for the following would cost about the same as those presently being used: Welding and Soldering; Photographic Developing; Paint Booth; Plastics; Ceramics; Graphics and Classroom areas. The exhaust fan for the small engine exhaust would be cheaper. The make-up air unit would be more expensive than the constant volume units presently being used due to its more sophisticated control system. Dust collection equipment would be cheaper, because of its reduced size, though this is mitigated by the addition of the secondary filter system and the additional electronic controls and monitoring panel. Overall, the dust collection system in total should not cost any more than those presently being installed and could cost less, possibly up to 25 percent less.

Short of removing some of the curriculum procedures requiring a ventilation system, no major cost cutting procedures can be identified that would be compatible with OHS standards.

7.3 OPERATION OF EXISTING DUST COLLECTION EQUIPMENT

The appropriate measures that should be taken for all existing dust collection systems and any that are installed in future applications are:

(i) the provision of copies of operating and maintenance manuals for all dust collection systems and components, and they should be made available to the school industrial education instructor(s), the school principal, the school jurisdiction's facility planning, maintenance personnel and curriculum consultant, as well as in permanent storage in an accessible library;

(ii) the setting, monitoring and adherence to a maintenance and cleaning schedule;

(iii) the occasional testing of the dust collection system to ensure that it is working properly; and

(iv) the installation of a monitoring device, e.g. a flow switch that would indicate reduced air flow.

7.4 HAZARDOUS MATERIALS

The school jurisdictions that have industrial education shops should take an inventory of all materials that they have in their shops, and all materials that they order for the shops. They should discuss it with the OHS Division to ensure that they minimize hazardous materials storage and use.

7.5 COMPUTER STORAGE

The microcomputers should be stored in another shop room that is pressurized, i.e. the instructor's office, or totally removed from the industrial education shop.

7.6 INTERIM MEASURES

Where school jurisdictions do operate industrial education facilties, and do not have adequate main dust collection and ancilliary ventilation equiment, they should maximize the use of personal safety protection of the students and instructors in all cases where such equipment is considered necessary by the Alberta Occupational Health and Safety Division. The use and prescriptive requirements of such equipment should be stressed in the learning environment.

7.7 FUTURE RESEARCH ACTIVITIES

Clearly, several additional sets of information must be collected to contribute to a greater understanding of circumstances in industrial education facilities. The following activities are recommended:

(i) the continuation of the measurements and perception surveys in all schools with shops in order to build a provincial overview of the existing circumstances;

(ii) the reinvestigation of all of the test schools once their dust extraction systems have been maintained;

(iii) a reinvestigation of some of the test schools in which instructor and student movements, personal inhalation and noise exposure tests (using portable samplers and dosimeters) could be made;

(iv) a longitudinal investigation of the instructors and students in some of the test schools to determine exposure to noise, dust and other contaminants over the period of one curriculum cycle; one school of each case considered which is the best case, average case and poorest case should be examined;

(v) continual monitoring of standards issuing agencies such as Alberta OHS, NIOSH, ACGIH and ILO to note revisions to exposure limits of hazardous materials; and

(vi) further work regarding the design details of the prototypical engineering system prescribed by Cheriton Engineering Ltd. contained in this report.

(vii) a review of the curriculum and its translation into shop projects as a means to reduce the creation of dust in the industrial education shops.

APPENDIX A

DISCUSSION OF OCCUPATIONAL EXPOSURE LIMITS FOR AIRBORNE TOXIC SUBSTANCES

Quotation Source: International Labour Office, Geneva, Switzerland

APPENDIX A

DISCUSSION OF OCCUPATIONAL EXPOSURE LIMITS FOR AIRBORNE TOXIC SUBSTANCES

A.1 INTRODUCTION

Many industrial nations appear to have given consideration to the issues of occupational exposure limits for airborne toxic substances. They include Canada, the United States, Australia, the Scandinavian nations, Japan, western Europe and Soviet bloc countries. Conferences have been convened for the purpose of drawing attention to standards that are accepted and used by government and research recognized agencies.

A.2 BASIC DISCUSSION REGARDING EXPOSURE LIMITS

Awareness to health risks related to pollution of the air in the work place has triggered action to reduce it both in legislative and voluntary terms. Concerns regarding this matter have led agencies to consider what substances are toxic, what concentrations are tolerable from the perspective of being inoffensive for the health of the person exposed. Hence, the critical issue is the determination of levels of concentration. The International Labour Office (ILO) indicates that the levels of concentration have been established on a "somewhat empirical basis, either taking into account the findings of epidemiological studies of exposed industrial populations, where they were available, or extrapolating the results of toxicological experimentation on laboratory animals for both acute and chronic toxicity. In a number of cases the demonstration of correlations between level of exposure and degree of health impairment (dose/response relationship) provided the basis for the establishment of exposure limits.

However, criteria for determining these limits are not uniform: they vary in time, and from one country to another. Therefore, these limits differ in practice from country to country. They may be set, for economic and social reasons, at a certain level to

prevent illness, or to protect the majority of workers from adverse effects, or to prevent the earliest demonstrable change from normal behaviour. The safety factor, generally included in all established exposure limits, may differ from country to country as will analytical methods for determining the concentration of these substances and for monitoring the environment. The refinement and improvement of old classic methods as well as the development of new methods of highest sensitivity for environmental control and health monitoring have contributed largely to the changes in exposure levels within the period of industrial development.

In practice these levels have undergone a continuing revision in the light of industrial experience and scientific research, which has led to a progressive lowering of the limits initially considered to be inoffensive. At the same time, a body of knowledge has been progressively built up on the health risks involved due to occupational exposure to these substances, in particular their chronic and long-term effects, and in parallel more reliable and precise criteria were developed with a view to assessing this information and making use of it in determining a "safe limit". Despite the continuing effort to achieve a more effective understanding of the biological reactions related to occupational exposure, experience has shown that the expression "safe limit" is inappropriate from a biological point of view, and that, at least for the time being, it is better to refer in general to them as "exposure limits". They are accepted as essential guides to the control of occupational risks. In industrialised countries a substantial body of data on environmental indices (measurement of actual exposure to the various hazardous agents) and the relevant changes in the health status (medical observation on exposed workers) has been accumulated. However, due to the magnitude of the technical means and resources which are required for organizing and carrying out the complex scientific work for obtaining the necessary experimental, clinical and epidemiological data, only a few countries have been able to set up the appropriate machinery for this work."

This is a rather pungent statement to those who are insensitive to the potential risks of toxic substances and who tend to hope for a lowering of standards related to occupational health and safety. Essentially, it appears that although exposure limits are established by legislation in Alberta and elsewhere, considerably more medical and experimental research in lab tests and in longitudinal surveys is required to fully

appreciate values that may be assigned as safe and not just apparently tolerable. It is important to note that exposure tolerance values are subject to the ambient conditions in which they have been stated, i.e. atmospheric pressure and temperature, and it appears that a different value may be assigned when more than one substance is present in the working environment. The values noted in this text refer to pure substances.

"The countries surveyed in the (ILO) document were selected as giving examples of different criteria adopted in establishing the exposure limits, the different meaning of the specified levels, and the various ways in which these limits have been made applicable to the industry. In this connection, it is interesting to note that in some countries they are issued as official regulations; in other countries, these lists are prepared by non-official bodies, but are recognized by the labour inspectorate. In other cases, the lists are not officially recognized by have a strong indicative value and are used as a guide for the control of the working environment. Criteria for classifying harmful dusts, methods of their sampling and assessment of their concentrations are basically different from those for chemical substances; they also differ widely from one country to another."

A.3 GENERAL EXPOSURE LIMITS

"The expression "exposure limits" appears in the Working Environment (Air Pollution, Noise and Vibration) Convention adopted by the International Labour Conference in 1977 ... it is not intended to define the meaning of the values specified in the various national lists. It is used as a general term and will therefore cover the various expressions employed in the national lists, such as "maximum allowable concentration", "threshold limit value", "permissible level", "limit value", "average limit value", "permisssible limit", "time-weighted average", "industrial hygiene standards", etc.

The definition of these various expressions is given where appropriate in the section on national lists. The purpose of this section is to make a general review of the various types of exposure limits which appear in the national lists and of the specifications by which they are often accompanied. It should also be noted that not

only these exposure limits have different definitions in the various lists, but also the same terms are used with different meanings. This is typically the case for the expression "maximum permissible concentration" which in certain countries indicates ceiling values, whereas in others it defines average concentrations.

The criteria and methods for determining exposure limits are not the same in the various countries. They vary in practice between the stringent USSR concept of maximum allowable concentrations (MAC), which in no case should produce biological or functional changes, and the more elastic approach of the ACGIH of the USA, whose threshold limit values (TLV) make allowance for reversible clinical changes. These values are in general established on the assumption of an eight-hour shift exposure, work of normal intensity, normal climatic conditions and an exposure-free period of 16 hours following the shift, during which full detoxication should ensue. When increased absorption may take place by reason of working overtime, or of increased breathing rates due to heavy physical work, to adverse climatic conditions such as excessive heat or humidity, or to work at high altitude, then some adjustment of these standards is necessary. It should also be pointed out that the values recommended or prescribed in the national lists have to be applied in the complex field of industrial hygiene and should therefore be interpreted by persons trained in this field.

When exposure limits were first established, they took the form of maximum allowable concentrations (MAC) or ceiling values, not to be exceeded at any moment. Subsequently, the American Conference of Governmental Industrial Hygienists (ACGIH) launched the concept of "time-weighted average" (TWA) concentrations which would represent a mean concentration allowing excursions above the level specified, provided they were compensated by corresponding excursions below this level during the workday. This concept is based on the assumption that TWA concentrations provide a more satisfactory way of monitoring airborne agents in the working environment and takes into account the effective occupational situation. The frequency of these excursions, their magnitude and their duration are not the same in the various countries which have adopted the concept of time-weighted average levels and are specified in the national lists. Generally speaking, the extent of these excursions is related to the magnitude of the permissible average concentration. The ACGIH, which

first established criteria in this connection, has adopted a rough scheme, by which the excursion factor, unless otherwise indicated, is the following:

TLV from	0 to 1	(ppm or mg/m^3)	: excursion factor	: 3
TLV from	1 to 10	(ppm or mg/m^3)	: excursion factor	: 2
TLV from	10 to 100	(ppm or mg/m^3)	: excursion factor	: 1.5
TLV from	100 to 1 000	(ppm or mg/m^3)	: excursion factor	: 1.25

Similar criteria are found in the Finnish, Italian and Swedish lists. The number of times the excursions above TLV is permitted and their duration should be based upon a number of factors, such as the nature of the contaminant, cumulative effects, frequency of spells, etc.

Obviously TWA are not applicable to fast-acting substances, such as irritants and narcotics, or to substances which are particularly toxic. In these cases a more rigid limit is necessary, called maximum allowable concentration or "ceiling" value. It is interesting to note that in recent years there has been a trend towards considering permissible concentrations as time-weighted averages rather than maximum concentrations. This is the present approach in the majority of national lists.

Another type of exposure limit is the "short-term exposure level" (STEL) which is a higher limit allowed for short exposures not exceeding a specified duration. They represent practically a ceiling value, limited in time, above the TWA level. In certain cases, national lists (Czechoslovakia, Romania) specify both an average and maximum limit. In these cases excursions above the TWA levels specified are permitted up to the maximum concentration prescribed.

The Occupational Safety and Health Administration of the USA refer to "permissible exposure limit" (PEL) values that are work-shift TWA levels, except where otherwise noted. The "immediately dangerous to life and health" (IDLH) concentration represents a maximum level from which one could escape within 30 minutes without any escape-imparing symptoms or any irreversible health effects.

Particulate matters are generally dealt with in separate sections of the national lists, and special rules are laid down for the assessment of exposure limits. In this connection the composition, physio-chemical properties, and size of the dust particles should be taken into account and sampling techniques and analytical methods specified.

The exposure limits usually refer to pure substances. In certain cases, which are specifically mentioned, they refer to technical products as these are likely to contain impurities responsible for the toxic action. In some other cases they refer to industrial processes which give rise to exposure to technical mixtures (i.e. petrols) or to complex toxic agents (i.e. welding fumes) of ill-defined composition. In latter cases reference is often made to one known component of the emission. Reference to the concentration of this component is also the most common procedure for monitoring the industrial environment. However, when dealing with mixtures of known toxic agents, a special formula is recommended for determining exposure limits ... This formula makes allowance for the levels of each component in relation to its exposure limit.

The information at present available about certain substances is considered to be insufficient for defining a concentration which would prevent ill effects. Substances of this group are sometimes included in national lists with a warning that the limit shown is given only as a guide for the purpose of technical prevention."

A.4 SPECIAL NOTATIONS

"Besides the name of particular substances, national lists bear capital letters or special notations, which are intended to give warning of a special risk. The more common notations are the following:

Carcinogenic risk notation. Some lists use a designation ... referring to the carcinogenic risk. Substances may be with or without an exposure level (USA, Switzerland, FRG, Sweden, Finland). Sweden specifies ... carcinogenic substances which may be used according to the instruction of the Labour Inspectorate.

Skin notation. In some lists, substances followed or preceded by a special symbol ... refer to the potential contribution to the over-all exposure through percutaneous absorption including mucous membranes and eyes, either by airborne or, more particularly, by direct contact with the substance. Characteristic substances are aniline, nitrobenzene, nitroglycol, phenol, and pesticides (USA, Belgium, UK, USSR, Switzerland, Netherlands, Sweden, FRG). This designation is intended to draw attention to appropriate measures for the prevention of cutaneous absorption so that the threshold limit is not invalidated.

Sensitization notation. Some lists use a designation ... referring to the possibility of skin sensitisation or other allergic reactions. Minimal quantities of such substances can cause sever allergic reactions, even when far below the exposure limits.

This warning is given for the protection of people with congenital or acquired sensitisation, or defects of the genetic system (FRG, Sweden, Switzerland).

Ceiling value notation. This designation is used (Belgium, Finland, Netherlands, Sweden, Switerland, USA) for substances for which it is believed that a specified ceiling value ... should not be exceeded.

Provisional notation. Some countries use a provisional notation ... This is used for substances where it is believed that insufficient data exist for establishing an exposure limit, but where nevertheless firm guidance for the protection of workers in production process is needed (Sweden, Switzerland). These substances are sometimes included in a special list, such as the "notice of intended change" in the ACGIH list, "tentative values" in the Australian list.

Technical reference concentration. This refers to the concentration which may serve as reference limit for protective measures ... TR concentrations are assigned only to dangerous substances for which exposure limits cannot be established. The application of these limits may enable the health risk to be diminished but it cannot be totally eliminated.

These exposure limits take into account technical possibilities and medical experience. They are provisional limits, pending improvement in the light of technical development, analytical possibilities and medical experience. They are in particular applicable for certain carcinogenic substances which cannot be eliminated from the environment or in industrial processes, and for which it is necessary to provide guidance for technical prevention."

A.5 PARTICULATE MATTER

"There are usually two categories of particulate matters for which exposure limits are provided in the national lists: the nuisance particulate and the fibrogenic dusts.

Nuisance particulates, from a biological point of view, are inert dusts which do not give rise, under the usual conditions of occupational exposure, to pathological irreversible changes in the lung tissues. Fibrogenic dusts, on the contrary, give rise in the long run to fibrotic changes in the lung tissues. Quartz and asbestos are the most important fibrogenic dusts. Their role in the occupational lung pathology is shown by the fact the national lists determine the exposure limits of mixed dust according to the content of quartz or asbestos."

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